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# THE COMBINED WEIGHT CLASS—RECTRIX PATTERN METHOD FOR DETERMINING SEX OF SHARP-TAILED GROUSE

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Inability to diagnose the sex of living sharp-tailed grouse has been a handicap in ecological studies of the species. Snyder (1) originally propounded a method employing the pattern on the median rectrices as an indicator of sex. He had observed that a longitudinal pattern of light and dark markings appears to be the badge of males; a pattern transverse to the feathers is characteristic of females, although the pattern on some females approaches a longitudinal design. The writer has applied this method in determining sex of 56 specimens and has found that 48 of them, checked by dissection, were correctly determined. The method, therefore, appears to be 85.7 per cent reliable.

Mr. Snyder (2) has communicated the results of a re-examination of the skin specimens in the Royal Ontario Museum of Zoology. Out of 76 adult specimens, the rectrix pattern of 65 (approximately 85.5 per cent) disclosed sex correctly, assuming that the labels were accurate. Nine birds (approximately 11.8 per cent) fell into an uncertain group because of the intermediate character of the pattern. One bird labeled female had a distinctly male pattern and one bird labeled male, a distinctly female pattern. These two birds (approximately 2.6 per cent) may indicate the percentage of complete irregularity of the rule, or error in sexing by dissection, or in recording the sex. Mr. Snyder's figures for museum specimens are in remarkable agreement as to percentage of reliability with those of the writer for specimens in the flesh.

While a sex indicator 85.7 per cent accurate is of great value, any other criterion which will serve to improve diagnosis is extremely desirable. During the past two years, 1,304 birds have been weighed and sexed in Minnesota and Wisconsin under the guidance of the Lake States Banding Cooperative. In plotting these data by weight classes with 50-gram intervals ranging from 601 to 1,100 grams, a direct relationship is found to exist between weights and sexes, the males being heavier than the females. In the lower weight groups, there are more females and fewer males, while in the higher weight groups, the proportion is reversed. In the intermediate groups, the proportion of males to females is more nearly equal.

The extent of overlapping between sexes in the various weight groups is somewhat dependent upon the number of males and females falling within those groups. Therefore, in the ex-

tremes of a normal weight curve there is little overlapping, while in the median region, overlapping is proportionately greater. It is in these latter groups that more errors in sex determinations appear in the weight-class method. By combining the rectrix-pattern method with the weight-class method, the errors in sex determination of the doubtful groups can be reduced to a point where they may be considered almost negligible.

The problem can be viewed from two angles, both assuming that rectrix pattern alone classifies birds into three categories, namely, male, female, and "doubtful." First, it can be stated that approximately 15 per cent of the birds fall into the "doubtful" group and that the remaining birds segregated as males and females are not subject to erroneous diagnosis. This, however, is illogical since the birds were classified on rectrix pattern and not on a chance basis, and because there is inaccuracy in the male and female groups as well as in the "doubtful" class. A second viewpoint can be taken, and this appears more logical: that the classification of any bird with certainty on the basis of rectrix pattern alone is possible 85 times out of 100 regardless of the weight of the bird.

Turning to weight as a second cri-

TABLE 1

| (1) Weight Class | (2) Sex | (3) Number of Birds | (4) Percentage Probability Male and Female (±7½%) | (5) Percentage of Total |
|---|---|---|---|---|
| 1,051–1,100[1] | M | 20 | .952 | .0015 |
| | F | 1 | .048 | .0007 |
| 1,001–1,050 | M | 107 | .899 | .0828 |
| | F | 12 | .101 | .0091 |
| 951–1,000 | M | 229 | .839 | .1756 |
| | F | 44 | .161 | .0337 |
| 901– 950 | M | 201 | .703 | .1541 |
| | F | 85 | .297 | .0652 |
| 851– 900 | M | 106 | .484 | .0813 |
| | F | 113 | .516 | .0867 |
| 801– 850 | M | 51 | .30 | .0391 |
| | F | 119 | .70 | .0913 |
| 751– 800 | M | 14 | .096 | .0011 |
| | F | 132 | .904 | .1012 |
| 701– 750 | M | 5 | .084 | .0038 |
| | F | 53 | .914 | .0406 |
| 651– 700 | M | 1 | .084 | .0008 |
| | F | 11 | .916 | .009 |

[1] The weight scale in the table applies to the great plains sharp-tailed grouse of the lake states region and not to the lesser races (inter-mountain or the northwest race which probably average smaller, or to the southern great plains birds which probably average larger).

terion of sex and applying it to all three categories, the percentage of error can further be reduced. In those instances where the rectrix pattern is "doubtful," the probability of a bird being male or female in each weight class can be deduced from the weights alone. The errors of classification by weights are

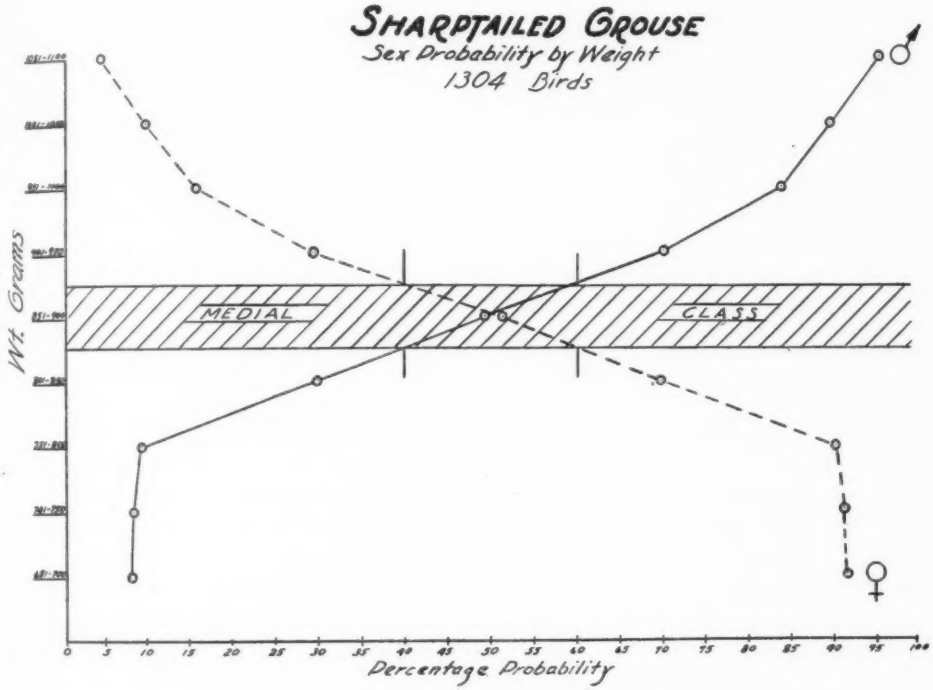


Figure 1

determined solely by the percentage of accuracy in assigning sex without dissection.

In the accompanying Table 1, column 1 is an arbitrary weight division by classes of 50-gram intervals; column 2 indicates the sexes according to rectrix pattern; column 3 refers to the actual number of birds by sexes falling within each weight class; column 4 is the percentage of probability of sexes for each weight group of the 1,304 total birds considered, i.e., any birds falling in the 651–700 gram weight class have a 91.6 per cent probability of being females and an 8.4 per cent probability of being males; and column 5 is the percentage of birds by sexes in each weight class of the total. The last column is not essential to the table and is presented only for information.

Assuming that 100 birds fall in the 1,051–1,100 weight class, the probability of males to females is 95.2 per cent to 4.8 per cent. In other words, it can logically be stated that 95 of the 100 birds will be males and 5 females. Likewise, by using the same method of deduction in the 1,001–1,050 weight class, the probability of males to females is

89.9 per cent to 10.1 per cent. The probability of being either sex becomes more nearly equal for birds that fall within the weight classes nearer the median group.

The preceding graph (Fig. 1) can be readily used in determining the probability of sexes in the various weight classes. For example, of birds in weight class 1,001–1,050, there is a probability that one out of every 10 will be a female. If successively lowered weight classes are considered, the probability of males to females becomes more nearly equal and the chances for erroneous sex diagnosis by weight becomes proportionately greater until the median class is passed, from which point the process is reversed. Any birds in the median groups should not be diagnosed by the weight method, since the probability of their being either sex is so nearly equal, ranging from 40 to 60 per cent.

As in all biometric tables, the error of random sampling decreases with the number of cases used. With the type of sampling used in this study, records of certain birds were eliminated. Weighing the same bird every few days does not indicate weight trends as well as weighing a larger number of birds at more infrequent intervals. Therefore, weights of individual birds made more often than every two weeks were not included. Only a few of the birds were weighed in different two-week periods. This method was used because weights fluctuate with weather conditions, and the figures obtained in this type of sampling are more indicative of average conditions. There is some possibility of erroneous diagnosis, of course, where emaciated birds are concerned. In all instances, birds that did not appear healthy were excluded from the tables. They should not be used by other investigators applying this method of sex diagnosis.

There is a tendency for the average weights to fluctuate in direct ratio to adverse weather conditions best exemplified by temperature changes for use in corrective adjustments. The average daily temperature for northern Minnesota from November 1, 1937, to April 15, 1938, was approximately 16° Fahrenheit; fluctuating from 1° below to 44° above on a nearly symmetrical curve. In weighing 376 birds during this period and grouping them in semi-monthly intervals, it was found that average weights ranged from 916.4 grams in the November 1–15 period to 842.2 grams in the January 1–15 fortnight. The average temperature for the former half-month was 32° above and for the latter, 1° below. Hence for an average drop in temperature of 33° these birds lost 74.2 grams each or an average of 2.25 grams loss in weight per degree of temperature drop. Likewise, from the period of January 1–15 to March 16–31, when the temperature ranged from 1° below to 44° above, each bird gained an average of 38.8 grams or .86 grams per degree of temperature increase.

The average temperature for the winter, November 1, 1937 to April 1, 1938 was 16°. Since sharp-tailed grouse were trapped throughout this period, that average applies to the data in Table 1. Any birds taken at temperatures higher or lower than 16° above zero must receive compensatory weighting before the table can be applied in sexing. For purposes of application, the

figures for average loss and gain per degree—2.25 and .86—are rounded out to 2 and 1 respectively. For every average daily degree higher than 16° above, 1 gram must arbitrarily be subtracted from the weight of the bird prior to sex diagnosis by the weight-class method, and for every average daily degree under 16° above, 2 grams must be added. For example, assuming that the bird is taken at 0° average daily temperature and that the drop to such low degree was gradual, it will be necessary to add 32 grams to the weight of this bird to compensate for the 16° below the average temperature upon which the weight classification is predicated. Likewise, assuming that a bird is taken at an average daily temperature of 30° above, it will be necessary to subtract 14 grams from the weight of the bird to compensate for the 14° above the average temperature upon which the weight chart was based. This does not apply in cases where there is a sudden rise or fall in temperature of short duration, because the weight of the birds will not fluctuate so rapidly.

Temperature decreases have more drastic effects upon the weight of sharp-tailed grouse than temperature increases. This appears logical since by the time the normal seasonal temperature decreases have caused the weight of a bird to drop, foods of concentrated nature are no longer available and even though the temperature rises, the same comparable weight increase is impossible.

It is realized that the figures presented in this study may be subject to criticism because most of the initial determinations of the 1,304 birds were made by the rectrix pattern method, which in itself is 15 per cent erroneous. The probability figures can, therefore, be considered accurate plus or minus 7½ per cent.

## ACKNOWLEDGMENTS

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# TRAPPING PENNED DEER

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Recently it was necessary to remove 18 Virginia white-tailed deer and one fallow deer from a 12-acre enclosure near Orion, Alabama. The enclosure, which was nearly square, was about equally divided into three pastures that opened into one another through large gates located at the junctures of the pasture-fences with the enclosure-fence. The two side pastures were ordinary upland broom-sedge fields whereas the center plot included a low, poorly drained area of bottomland hardwoods.

Reported as having been introduced from Michigan, the deer had been living under semi-domestic conditions for at least seven or eight years. Originally collected to indulge a whim, they apparently represented a liability since the death of their former owner. Mortality in the band must have been great, for their numbers were little higher than the original. The animals appeared so tame that suggestions for catching them ranged from "roping" them with a lariat to "bull-dogging" them.

Following a reconnaissance of the enclosure, however, it was decided to catch the animals in the center pasture by some remotely-controlled mechanical means. For years all pasture gates had remained open, and any one of them would have served as a suitable place for a trap. However, the northwest gate of the center pasture (Fig. 1), or the one farthest from outside disturbances, was selected. Prevailing southwesterly winds would carry scent of drivers readily toward this point, and yet dissipate the scent of a trap operator located either north or east of the trap. In addition, a heavy grapevine that draped the larger portion of the north fence had already formed a natural tunnel through which the deer were accustomed to passing; and this it was believed would be useful in lending a natural effect to any structure that might be erected.

After preliminary experimentation, the trap illustrated in Figure 2 was built of rough, weathered lumber against the north fence of the center pasture. From the south side of the entrance to this trap, a drift fence was extended for about 60 feet at an angle of approximately 30° from the long axis of the trap.

The trap in itself was merely a narrow, solid-wall corral in which several animals could be confined at one time while awaiting loading. To facilitate crating, a portable, enclosed chute about 8 feet long, tapered from an entrance 3 feet wide and 4 feet high, to an exit 30 inches wide and 36 inches high, was constructed in two parts so that it could be moved readily into position when needed. This chute was entirely open at the entrance; but at the exit, it was fitted with a screen drop gate and a solid drop gate, both to be worked by hand (1). The gate trigger assemblies are illustrated in Figure 3.

The first attempt to trap some of the animals was disastrous. Despite the fact that they had been under semi-domestic conditions for so long, some

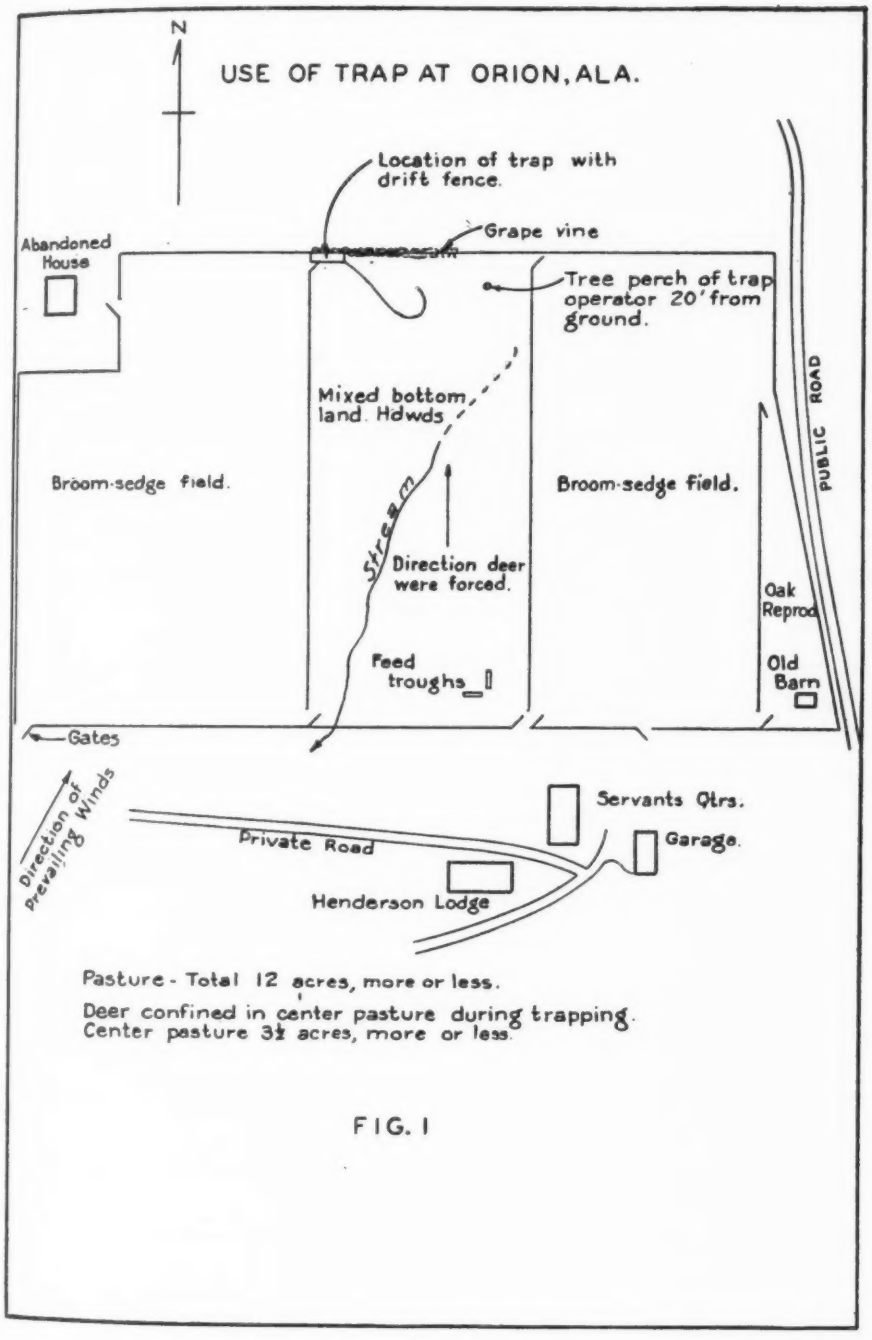
N
USE OF TRAP AT ORION, ALA.
Location of trap with drift fence.
Grape vine
Abandoned House
Tree perch of trap operator 20' from ground.
Mixed bottom land. Hdwds
PUBLIC ROAD
Broom-sedge field.
Broom-sedge field.
Stream
Direction deer were forced.
Oak Reprod
Feed troughs
Old Barn
Gates
Direction of prevailing Winds
Servants Qtrs.
Private Road
Garage.
Henderson Lodge
Pasture - Total 12 acres, more or less.
Deer confined in center pasture during trapping.
Center pasture 3½ acres, more or less.

FIG. 1

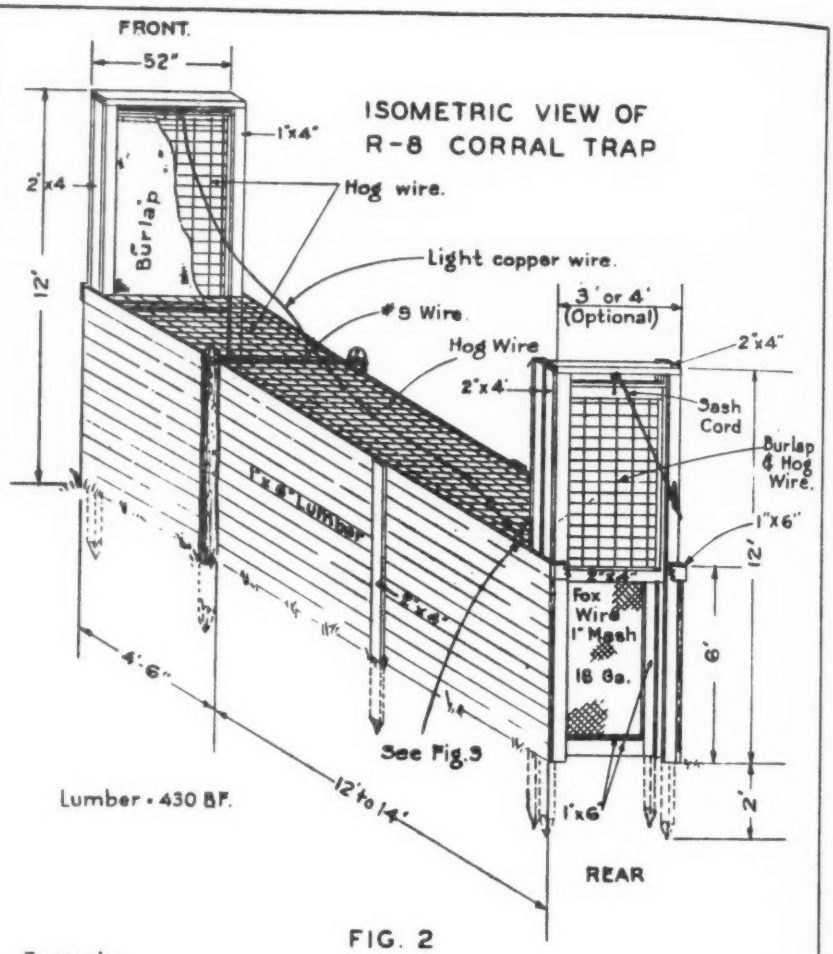


FIG. 2

Remarks:

May use:
(a) Tel. split tree insulators instead of 2" staples.
(b) Rough lumber instead of dressed allowing for difference in sizes.

All gate guides, posts and side braces buried in ground 1 to 2 feet.

May be necessary to brace gate guides with diagonal 1"x4" supports

Width of double gates at loading end optional depending on whether loading chute will be tapered or not.

Fasten burlap with ½" staples placed across 1 strand of baling wire.

All gates 5½' long.

Leave sufficient slack in rear gate trigger trip wire to allow front gate to close ½ way before releasing rear gate.

Blacken sash cord to make less conspicuous.

Front gate released by hand using insulated copper bell wire.

Top and bottom of all gates backed with 1"x4" or 1"x6" lumber.

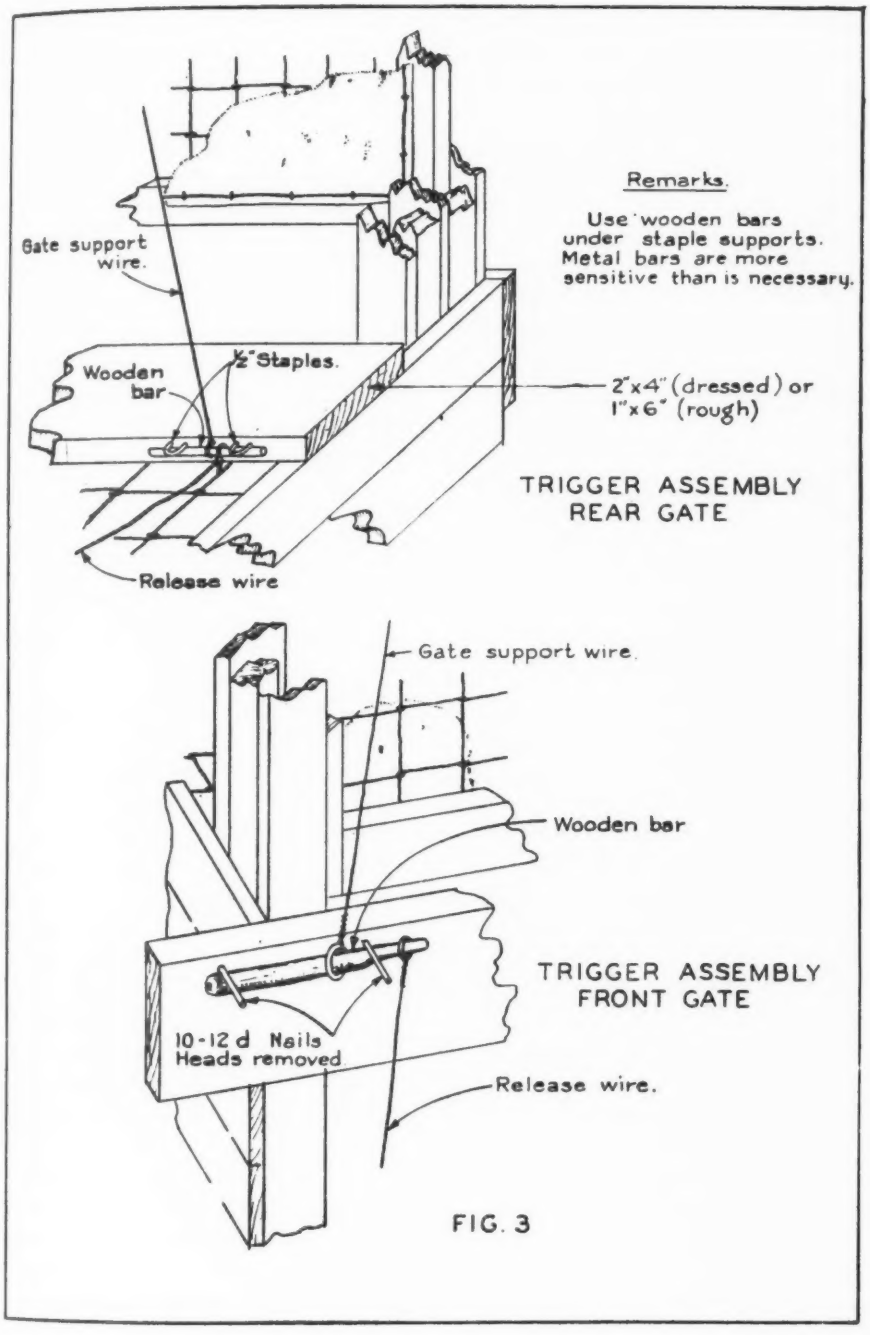
Remarks.
Use wooden bars under staple supports. Metal bars are more sensitive than is necessary.
Gate support wire.
Wooden bar
½" Staples.
2"x4" (dressed) or 1"x6" (rough)
TRIGGER ASSEMBLY REAR GATE
Release wire
Gate support wire.
Wooden bar
TRIGGER ASSEMBLY FRONT GATE
10-12 d Nails Heads removed.
Release wire.

FIG. 3

of them even having been born and raised in the enclosure, they were little more amenable to driving than thoroughly wild animals. Due to a lack of understanding of this fact and a complacent feeling that all would go well, the first two attempts resulted in stampeding the band, causing one to break its neck and another to break a leg.

It was finally understood by all participants that the utmost patience and care were necessary, and spectators were discouraged as much as possible. The trap operator was cautioned to remain absolutely quiet in his perch 20 feet above the ground and 75 feet from the entrance. Drivers were reduced to a minimum, and instructed to stand completely immobile when the band showed signs of stampeding.

The method, as finally worked out to satisfaction, took the guise of carefully herding the deer to the trap rather than driving them. At first the entire band was cut into several groups in either the east or the west pasture. One of these was then permitted to enter the center pasture through an open gate, after which all gates of this pasture were closed and herding started. Four men, spaced about 60 feet apart, began slowly working their way toward the north fence, stopping frequently when the deer ahead of them became restless, and occasionally waving slightly when one or several animals had apparently decided to break back through the advancing line. Through great patience and slow progress, the drive line would finally come to a final stand across the pasture about 200 feet south of the trap. Almost an hour would be consumed, the distance traveled being about 500 feet.

For the next hour the drivers would hold the deer in the northernmost 200 feet of the pasture, perhaps moving up another 50 feet or less. During this procedure the greatest care was required not to harass the animals too much, but to push them just enough to cause them to seek escape at every likely point along the farther fences, including the location of the trap.

Eventually one or several deer would enter and investigate the trap, perhaps for its possibilities of affording escape. As the doors of the structure were of the drop type and would kill an animal if they were to fall on it, the operator was required to use the utmost discretion in releasing them. Generally with a little patience it was possible to catch three or four animals at a time. One might enter the trap, inspect it for a while, leave it again, only to return with one or two others following. Groups were caught merely by waiting until the animals had completed their preliminary individual investigations, and had decided to conduct another, *en masse*.

After the trap had been sprung, all deer on the outside generally bolted a short distance or, if under the influence of an excitable animal, stampeded to the south end of the pasture. At such a time, all personnel remained motionless until the animals stopped running.

Crating began as soon as the loading chute was set into place. This followed in general the practice used on the Pisgah National Game Preserve. One deer was allowed to enter the loading chute at a time, whence it was forced into the crate (1). In this operation it was found most advantageous to remove both end doors of the crate and cover the front with the screened gate of the loading chute. In this manner,

a deer was more apt to seek further escape through the crate, and delayed less in entering it. If continued quiet was maintained during the operation of crating, the trapped animals remained relatively calm.

Injuries may occur in the trap if the greatest care is not taken in providing for all possibilities. The ground in the trap must be firmly packed, leaving no holes through which a leg may be thrust and broken. Especially strong and unruly individuals should be caught alone so that they cannot injure others in their attempts at escape.

Each evening the trap gates were propped open and the trap baited with apples and mistletoe. This was not done to improve the possibility of capturing the deer through the use of an automatic release mechanism, but rather to accustom them to visit the structure of their own free will. Apples had been found a satisfactory bait on the Pisgah Game Preserve, and mistletoe had been found most useful by the Biological Survey in its deer trapping operations on Bulls Island, South Carolina. Both items of food were consumed readily outside the trap; but during the short time in which the project was conducted, they were rarely touched when placed inside.

Cost of trapping was considerably lower than in previously tried methods. The entire trap, exclusive of the crates, cost about $32.00. Labor in securing 19 deer during three days' operations, exclusive of the cost of supervision was $18.00, at $1.50 per man day. This averaged $2.63 per deer caught, and would have been much less if more animals had been available for trapping. Crates were built by a local lumber company at $3.05 each. By returning empty crates after completion of a shipment, twelve were sufficient for removing all of the deer.

## CONCLUSIONS

1. Penned deer that are more or less accustomed to the presence of humans may be trapped by a modified drive wherein extreme patience and care are exercised in order to prevent injury.

2. Such herding of the animals into a trap is best accomplished if they are first confined to a smaller enclosure within a larger, so that during their attempts to escape into the latter they will be more likely to seek passage through the trap.

3. Semi-tame deer are apparently as little amenable to confinement in close quarters as are thoroughly wild animals. They seem to be just as excitable and losses due to fright may be expected to be just as great. Semi-tame animals probably do not have the sense of caution as well developed as do wild deer, especially as regards entering recently erected structures.

4. A semi-tame deer is as likely to burst suddenly into the headlong flight of a stampede and kill itself against an obstacle as is a wild animal. The slightest motion on the part of a driver at a critical time may cause this.

5. An interesting point in deer psychology is that a band of animals being worked toward a trap will generally follow the member that initiates action following a moment of inertia in the group. This characteristic results in the most nervous or excitable animal generally assuming "leadership," all others following it, even though this same animal on a separate occasion may follow some other individual that temporarily initiates action. It, therefore, develops

that the most excitable individual, having apparently discarded dependence on the others, becomes increasingly panicky, while they still retain their trait of blindly following the "leader" and, with an occasional exception, remain complacent and undisturbed, even going so far as to feed during moments of rest. This characteristic of herd psychology was observed without exception in each band that was driven.

6. The cost of securing penned deer by a method of working them into a trap is far below that of any known method of enticing them into one, being in this operation $2.63 per deer, including initial expense of construction of the trap or about $1.00 exclusive of this cost.

7. The method indicates possibilities of capturing wild deer by a similar system wherein the animals may possibly be guided by drift-fence wings, and urged most slowly and patiently into a series of smaller elongated or tapered enclosures, and finally into a corral-type trap. Apparently past failures in driving deer were occasioned by improper and hasty driving with the idea that deer could be handled like cattle.

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# NORTHERN YELLOWSTONE WINTER RANGE STUDIES

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There is a dearth of accurate information on the magnitude of the original big game population of the area that is now Yellowstone National Park and on the extent to which the plant cover of this region was utilized by herbivorous game animals. The accounts of the early explorers of the Yellowstone Park country do not mention the presence of large herds but their visits were nearly always made during the summer months when the animals, unrestricted by deep snows, could roam all over the country and were scattered about in small bands. For this reason it was difficult to estimate or visualize accurately the numbers of game.

Since about 1880 however, increasing numbers of game animals, principally elk, were reported. There was sufficient forage within the park for all of the animals during the summer months but in winter when, due to deep snow, available range became restricted to comparatively small areas in the northern part of the park, large numbers of animals migrated down the Yellowstone river to lower valleys outside of the park where forage was abundant and a less rigorous climate prevailed. But with the advent of the settler into these valleys the more desirable lands were preempted and became unavailable as a source of winter forage to the Northern Yellowstone game herds which now became chiefly dependent upon the range within the park at all seasons. The practical confinement of all these animals to the park caused heavy concentrations during the winter when, due to climatic conditions, only comparatively small areas in the northern section of the park remained available to them. These areas, which will henceforth be referred to as the Northern Yellowstone Winter Range (Pl. 18), consist largely of windswept ridges and flats of gravelly and rocky soil. While the game animals managed to survive on this limited range during mild winters, they suffered heavy losses during the more severe winters. Further, the continued heavy use of this range by excessively large numbers of animals had detrimental effects upon the growth and succession of its plant cover. Though perhaps only slightly perceptible in the beginning when climatic conditions were favorable, the deterioration became progressively more apparent in later years and reached its climax during the drouth period of 1931 to 1934, when serious denudation, soil erosion, stunting of the better forage plants, and intrusion of new and mostly obnoxious plants called forcible attention to the impaired state of the winter range.

The Yellowstone Park administration recognized the bad condition of the winter range and inaugurated an extensive study thereof as early as 1928. Based upon this preliminary work, an intensive and systematic investigation was carried out by the ranger personnel beginning with the winter of 1934–35. This study was made during the six months, November to April, inclusive, and included monthly observations of climatic con-

ditions and their effect upon range and game, and of range utilization, besides game counts, mapping and planimetering of the available range (Pl. 19-A), and computing the game carrying capacity.

The studies were continued each summer, employing chart plots, the square-foot-density method of range evaluation, and volume and browse plots. They revealed progressive and retrogressive plant successions, changes in plant densities and annual volumes of forage, and the effects of severe browsing on certain important plants. The data obtained were intended to be used as a basis for the management of the northern Yellowstone game herds.

The climatic and forage conditions that prevail on this winter range and also the number of animals that forage there vary greatly from year to year and data obtained during any one winter are not sufficiently representative to serve as a guide to management. It is, therefore, necessary to compile results for several winters to obtain a true impression of conditions that may be expected to prevail on the winter range during an average or representative year.

This paper gives in condensed form the information gathered during the winter of 1937–38 and the ensuing summer, and a compilation of the data for the 1934 to 1938 period.

## CLIMATIC CONDITIONS

Winter conditions in Yellowstone Park are seldom of a nature that would make the region, or more specifically the winter range area, an ideal wildlife habitat. Winters may be marked by excessive snow depths and low temperatures or other extremes, or a series of severe winters may be broken by an unusually mild winter and then resume its former trend. Although these conditions are sometimes referred to as abnormal, they are characteristic and must be accepted as normal for the region. These seasonal climatic factors are basic and have a definite bearing upon the amounts of forage available to the game animals and upon their health. Climatic conditions and their effects upon range and game during the winter of 1937–38 were as follows:

Snow during November was normal and large scale game migrations from the summer to the winter range did not get under way until the latter half of the month. There had been an abundant growth of forage and the amount consumed was scarcely noticeable though by the end of the month practically all of the Northern Yellowstone game herds were using the winter range. Unseasonal rains occurred early in December and were followed by low temperatures that transformed the water-soaked snow into a nearly solid icy crust that remained for most of the winter. In large areas the snow crust was so dense that the animals there, principally elk, were unable to paw through it and get forage. The amount of available range, therefore, was sharply restricted early in the winter. Overgrazing and utilization of abnormal amounts of browse in the upper range was already reported in December. The higher sections of the winter range were the more severely affected because of the heavier layer of snow there. In consequence there was a migration of large numbers of elk and other game animals, producing a heavy concentration in the lower range areas.

Also because of this condition many

elk migrated from the park to the adjacent national forest where large numbers were killed by hunters. Increasing snow depth and additional crusting of the snow during January and February further restricted functional winter range and brought about acute forage shortage during the latter half of February. The herbaceous plant cover had been consumed by the game animals to an extent that threatened its exhaustion and the animals were subsisting largely on browse. Not only were they heavily foraging on the more palatable browse, willow and aspen shoots, but they were also taking notable amounts of such less desirable types as sagebrush and Douglas fir. This serious situation was temporarily relieved early in March when rising temperatures melted the snow on the more exposed slopes and made forage accessible to the game animals. But this was a short-lived respite as severe snowstorms occurred during the latter half of March and the range was again covered with a deep blanket of snow. An up-country migration of elk, that had been in progress since the favorable weather early in the month, was reversed by these storms. Again large numbers of game animals were concentrated on a comparatively small area on which the plant cover had been all but depleted during the preceding months. Many of these animals were now observed to be in a weak and emaciated condition and a large number of elks were found dead from malnutrition.

Higher temperatures early in April brought about a general thaw that took off much of the snow cover and made accessible abundant forage that had been unavailable to the animals during the winter. A slow, up-country movement of elks continued during all of the month but reached very little beyond the upper limits of the winter range and most of the game herds were still within that area on May 1.

The snow had largely disappeared from the winter range at the close of the November to April study period and the game animals were recuperating from the hardships of the winter. Many animals, chiefly elks, were in a very weakened condition and it was evident that some of these would still die though forage was then plentiful.

An average of climatic data obtained from three weather stations in representative areas of the northern Yellowstone winter range at the Buffalo Ranch, Tower Falls, and Mammoth Hot Springs and also of the field data gathered by the study personnel is presented in Table 1 (next page).

## GAME CARRYING CAPACITY OF THE WINTER RANGE

A forage acre factor (F.A.F.) of .16, obtained from the winter range reconnaissance data and a forage requirement (F.R.) of 0.5 forage acres per elk per month or 3 forage acres for the six-months winter period, were used in computing the winter range carrying capacity for each winter of the 1934 to 1938 study period. The forage requirement for elk was arbitrarily set, giving due consideration to the figure of .538 F.A. per month for each elk as given by Rush[1] in his "Northern Yellowstone Elk Study" and to observations on the feeding habits of elk.

[1] Rush, W. M. Northern Yellowstone Elk Study. Montana State Fish & Game Commission. April, 1932.

TABLE 1

| | November | December | January | February | March | April |
|---|---|---|---|---|---|---|
| Temperatures<br>Maximum<br>Minimum<br>Mean | <br>55°<br>−7°<br>30.1 | <br>44°<br>−20°<br>20.1 | <br>42°<br>−37°<br>16.5 | <br>51°<br>−22°<br>25.8 | <br>54°<br>−8°<br>30.5 | <br>74°<br>−3°<br>37.7 |
| Number of stormy days | 14 | 24 | 20 | 13 | 12 | 0 |
| Snow fall | 16.1″ | 17.7″ | 26.0″ | 14.6″ | 28.1″ | 2.5″ |
| Snow depth | 5.3″ | 11.0″ | 17.2″ | 18.5″ | 17.0″ | 9.0″ |
| Condition of snow | loose | severely crusted | partly crusted | partly crusted | partly crusted | mushy, broken cover |
| Amount of available range in acres | 232,002 | [1]163,295 | [1]110,338 | 100,936 | 104,507 | 161,547 |

[1] Included in these figures are range areas of considerable size on which only the portions of forage plants that extended above the heavily crusted snow were available to the animals.

There were available during the average month of the winter 1937–38, 145,437 range acres. This figure multiplied by the forage acre factor of .16, gives 23,269 forage acres. This number of forage acres, divided by the forage acre requirement of the elk, or 3 forage acres, places the carrying capacity of the winter range within the park at 7,756 elks.

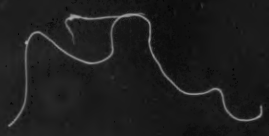
In addition to the wapitis or elks, there were also antelopes, deer, bighorn sheep, and bisons or buffaloes dependent upon the winter range for subsistence. In order to obtain the correct elk-carrying capacity of the range it was necessary to convert these additional animal units according to their forage requirements into elk units and deduct the number of units thus obtained from the above 7,756 elk units.

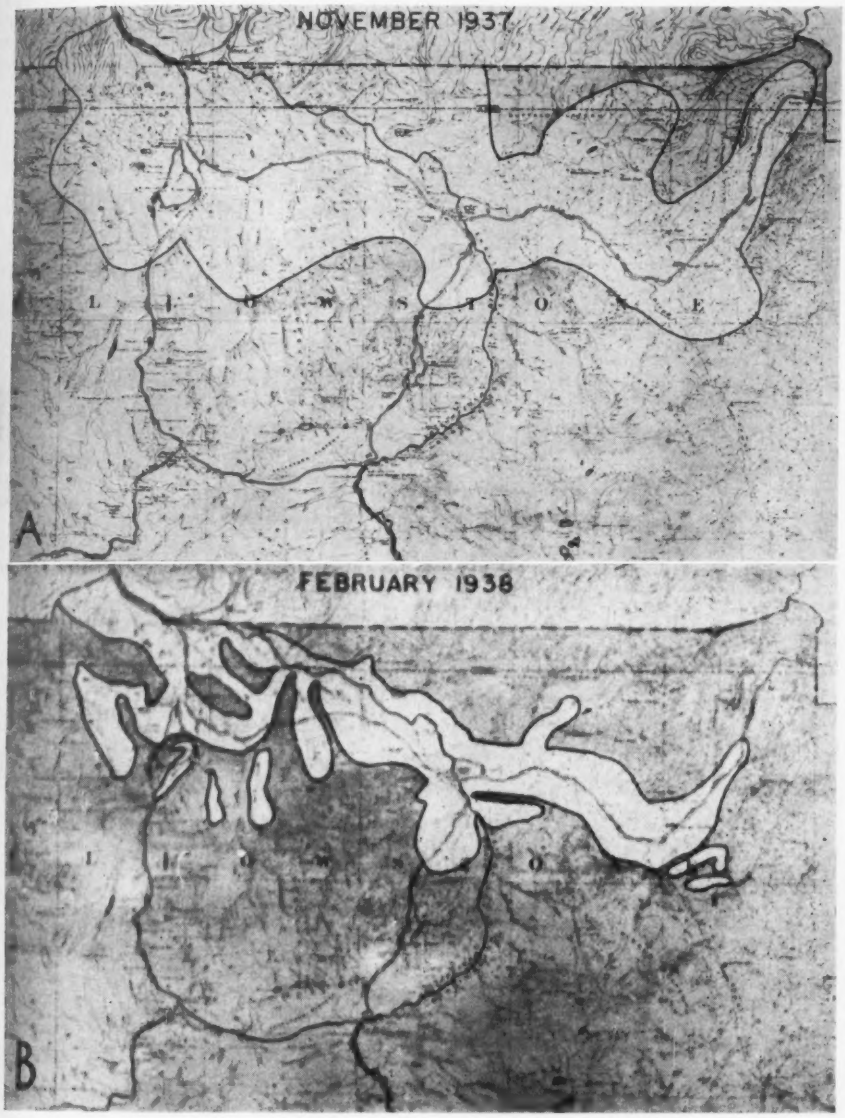
Three deer or three bighorn sheep were considered equal to one elk unit and one buffalo equal to 1½ elk units in forage requirements. The antelopes were omitted because they are believed to compete with elks less than the other animals listed and also to allow some compensation for the fact that bighorn and deer do not compete 100% for forage with the elk. Conversion of the forage requirement units of these animals into those of the elk gave these results:

| *Species* | *Number using range* | *Forage requirements in elk units* |
|---|---|---|
| Deer | 817 | 272 |
| Bighorn | 175 | 58 |
| Buffalo | 245 | 367 |
| | | Total 697 elk units |

The elk carrying capacity of the winter range for the average month was then 7,756 minus 697 or 7,059.

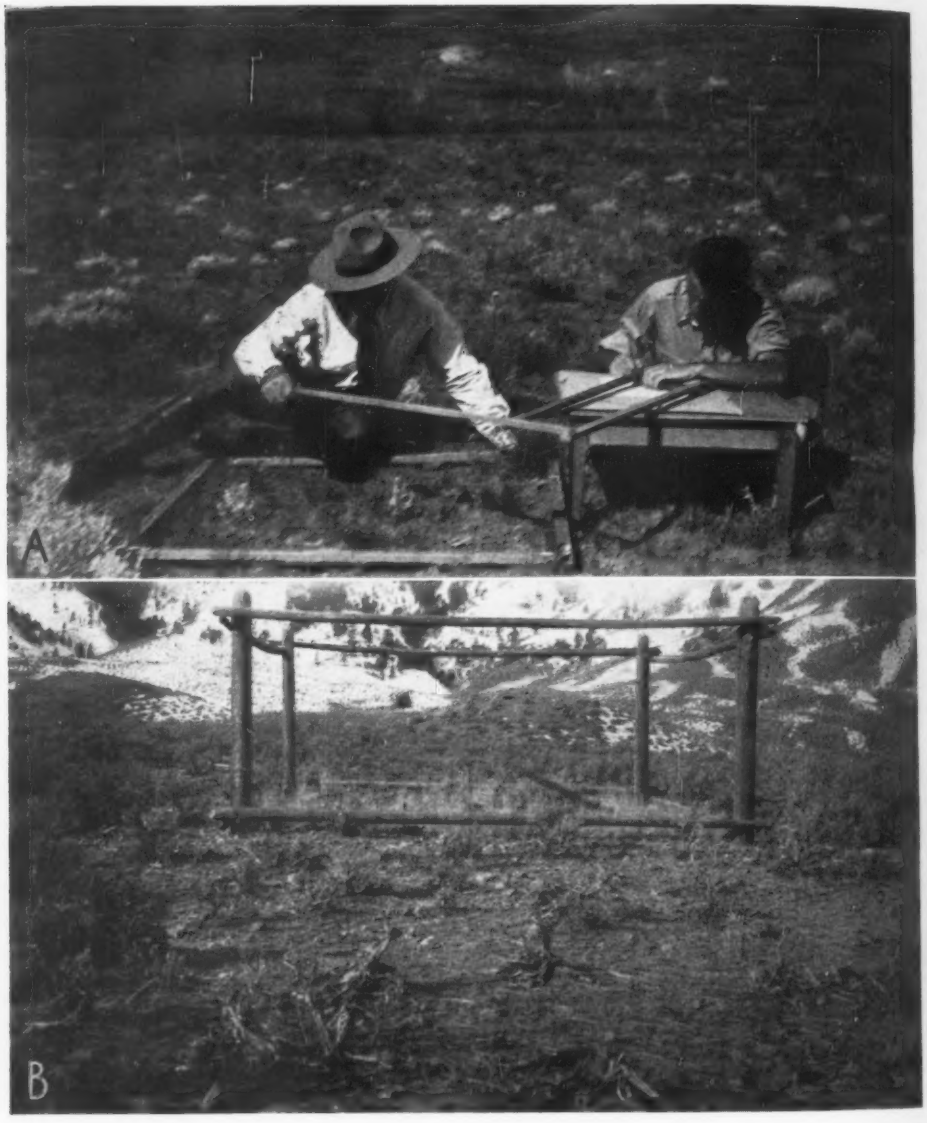
There occurs in every winter a period when available range becomes very restricted. This usually takes place in February and March (Plate 18-B). The average number of range acres available in February and March was





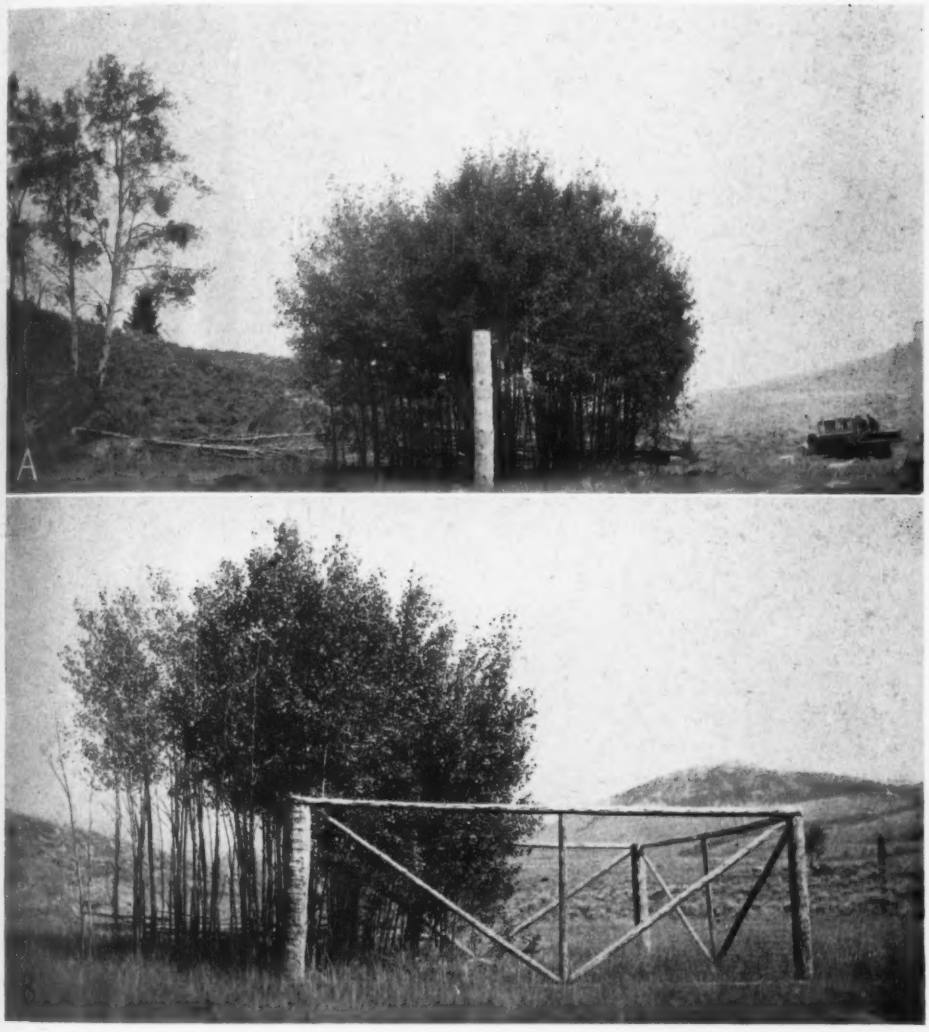

A. (*Upper*)—The lighter outlined area represents the maximum range available to the game animals during the winter.

B. (*Lower*)—Snow sometimes severely restricts the amount of winter range.




A. (*Upper*)—Charting a study plot on northern Yellowstone winter range.

B. (*Lower*)—Excessive utilization of grasses and sagebrush shown in foreground in contrast to better forage in protected plot.



A. (*Upper*)—Half of this formerly protected stand of aspen was enclosed by a game-proof fence.

B. (*Lower*)—One winter's excessive browsing by game animals very markedly affected the unprotected half.

A. (*Left*)—Overbrowsing kills trees.

B. (*Above*)—Aspen reproduction killed by excessive browsing.

102,721. This converted into forage acres (102,721×.16) is 16,435. The carrying capacity during the February–March period for all game animals, given in elk units, was 5,478. The elk carrying capacity of the range, after deducting the 697 other animal units using this area, was 4,781.

Since all of the animals upon which continuance of the herd depends must pass through this period, it must be given consideration in determining the winter range carrying capacity. It is not the sole factor on which the carrying capacity should be based as apparently due to the almost yearly recurring forage shortage, a stamina has been developed in the surviving animals that permits them to live through such periods without suffering permanent physical injury so long as the dearth is not excessive. It is, therefore, believed that a compromise figure between that representing the elk carrying capacity of the range for the average winter month, i.e. 7,059 units, and the figure of 4,781 elk units arrived at as the carrying capacity of the critical period should be accepted as indicating the true carrying capacity for the winter range under the conditions that prevailed during the winter of 1937–38.

Estimating that the very restricted range condition prevails during only one-third of the winter, the elk carrying capacity of the range within Yellowstone Park in 1937–38 was arbitrarily placed at 6,307.

The winter range extends to the north of Yellowstone Park onto the Absaroka National Forest and the carrying capacity there for the 6-months period was given by Forest Service officials as 900 elks. This figure, added to that for the Park, places the total elk carrying capacity of the northern Yellowstone winter range during the winter of 1937–38 at *7,207 elks*, barely sufficient, provided the herd was well distributed.

In order to obtain the elk carrying capacity of the winter range for an average year it was necessary to compile the winter range study data of a number of years and to draw an average therefrom. (See Table 2.)

TABLE 2

| | *1934–35* | *1935–36* | *1936–37* | *1937–38* |
|---|---|---|---|---|
| Average number of available range acres | 131,586 | 124,221 | 172,844 | 145,437 |
| Forage acres | 21,053 | 19,876 | 27,655 | 23,269 |
| Carrying capacity, all game animals | 7,017 | 6,625 | 9,281 | 7,756 |
| Carrying capacity, elk alone | 6,357 | 5,933 | 8,579 | 7,059 |
| Amount of available range February–March period | 93,274 | 80,489 | 109,326 | 102,721 |
| Carrying capacity, all game animals, February–March | 4,972 | 4,292 | 6,469 | 5,478 |
| Carrying capacity, elk alone, February–March | 4,314 | 3,600 | 5,191 | 4,781 |
| Elk carrying capacity of winter range on adjacent National Forest | 900 | 900 | 900 | 900 |
| Elk carrying capacity of combined winter range of Yellowstone Park and National Forest during February–March period | 5,214 | 4,500 | 6,091 | 5,681 |
| Adjusted carrying capacity of November–April period | 7,010 | 7,000 | 8,100 | 7,207 |

The average annual elk carrying capacity of the northern Yellowstone winter range over the four year period was 7,334.

### RANGE UTILIZATION

As was the case for a number of years herbaceous plants on the winter range again became depleted during the winter of 1937–38 because of over-utilization by an excessively large number of game animals. The depletion was of a more serious nature that winter because it occurred earlier than usual and the animals were forced to subsist on browse for a longer time. The parts of the winter range most affected were the bare exposures in the upper areas and more importantly, the range in the Gardiner region which consists largely of the north and west slopes of Mount Everts and the low foothills of Sepulcher Mountains. Within this region lies all of the Yellowstone Park antelope winter range as well as the major portion of the blacktail deer and bighorn sheep range. The amount of utilization of this latter area and degree of game concentration thereon during the January–March period is stated in the following table (3):

TABLE 3

| | |
|---|---|
| Available range area, January–March period | 15,711 acres or 14.9% of all available range within park. |
| Number of forage acres | 2,513 |
| Elk carrying capacity, 3-month period (2,513:1.5 F.A.R.) | 1,668 |
| Number of elks using this area | 2,486 or 34.7% of elks counted within park. |
| Number of antelopes using this area | 786 |
| Number of deer using this area | 375 |
| Number of bighorn sheep using this area | 95 |

Examination of this table shows that there was only enough forage on this range for approximately two-thirds of the number of elks counted there, not to mention the other game animals using it. It is true that the game concentration in this area reached its peak during the January–March period. However, the number of animals that used this range during the remainder of the winter, while perhaps not so great, also exceeded its carrying capacity.

Under normal conditions the elk feed on grasses, weeds, and small amounts of browse and this is also largely true for the bighorn. The deer consume grasses and weeds as well as considerable browse. Antelopes, however, consume very little grass but a great deal of weeds and browse. It is obvious that some competition for forage exists under normal conditions but when the herbaceous plant cover has been consumed the animals are all dependent upon browse and competition may then reach nearly 100%.

The range in the Gardiner region is of the sagebrush-grassland type and since antelopes subsist to a very large extent upon the leaves of sagebrush in this region it is well suited as a winter range for them. However, increasing areas of dead sagebrush may be seen in this section and it is obvious that the existence of this valuable range shrub is threatened (Pl. 21-B). In order to determine whether this condition was brought about by over-utilization or by other agencies, twelve experimental plots, each 100 square feet in area, were established on the range. Plots 1–3 were located on areas not frequented by antelopes and only

moderately used by elks, while the remaining 9 plots were distributed over the antelope winter range. The crown of each sagebrush plant within these plots was divided in halves by placing a red string over the center of each plant crown. Then in October, 1937 the foliage and green twigs of half of each plant crown were clipped and in April, 1938 the remaining halves were clipped. The weights of these clippings air dried were as follows:

| | *Weight of clippings in grams* | |
|---|---|---|
| | *October, 1937* | *April, 1938* |
| Plots 1–3 | 1,280 | 925 |

The difference between the two weights, 355 grams, represents the proportion of utilization during the 6-month period, which was 28.5%.

Plots 4–12 on antelope winter range that is also heavily utilized by elks and deer and to a much lesser degree by bighorn sheep, yielded the following results:

| | *Weight of clippings in grams* | |
|---|---|---|
| | *October, 1937* | *April, 1938* |
| Plots 4–12 | 1,537 | 287 |

The difference between these two weights is 1,250 grams making the proportion of utilization 81.3%.

Utilization of sagebrush on the area represented by plots 1–3, which was shown to be 28.5%, was not sufficiently intense to affect seriously the growth or perpetuation of the plant. In the area represented by plots 4–12, however, where the utilization of sagebrush was found to be 81.3%, it amounted to nearly complete consumption of the annual growth. Obviously continued browsing of the plant to that degree must ultimately lead to its destruction.

In the course of an antelope winter range survey, twenty-two sample plots of 100 square feet each were located on representative sections and the amount of dead sagebrush in each plot ascertained by the square-foot-density method. In this manner the average amount of dead sagebrush was found to be 65%.

Maintenance of sagebrush in the Gardiner region is of primary importance because it is a major forage source for the antelope in the only winter range suitable for these animals within Yellowstone Park. The value of the sagebrush is not confined to the forage it produces as the plant also serves to retain snow and resulting moisture on the windswept and arid range. Moreover it furnishes badly needed protection to the smaller but none the less valuable forage plants during periods of high temperatures and excessive evaporation. The partial extermination of the sagebrush already has had a very detrimental effect on grasses and other valuable plants.

Excessive game concentrations on the comparatively small areas available to the animals during the acute forage shortage of February–March resulted in the practically complete consumption of forage plants and that part of the range took on a "swept-up" appearance by the end of the winter. This was particularly true of the Gardiner area.

Forage plant depletion and consequent range deterioration was primarily brought about by use of the range by more than 10,000 elks. The excess load carried by the winter range is evident from a comparison of this figure with the number of 7,207 shown to be the elk carrying capacity of that range during the winter of 1937–38.

### STATUS OF THE WINTER RANGE

The destructive effect upon the range of overutilization and unfavorable climatic conditions especially when they occur simultaneously has been mentioned. In the 1936–37 range studies the writer found by the use of protected and unprotected plots that 72.2% of the loss in plant density was due to drouth and 27.8% to overgrazing although during the growing season of 1937 some density loss had already been recovered under the favorable climatic conditions of that year.

Continuance of these favoring circumstances—slow melting of the snow on the range in the spring and good distribution of rainfall during the growing season of 1938—made for further range improvement. Also, the range restricting factors operative during the winter of 1937–38 resulted in a large amount of plant matter remaining on the range in inaccessible areas. This decaying vegetative matter helped to enrich the soil, was an important factor in retaining soil moisture, and also aided germination of seeds.

In order to ascertain the effect of these and other influences on the plant cover of the winter range, a reconnaissance of the area was made in the summer of 1938 by means of the square-foot-density method. Transect lines were run over the winter range so as to assure representative sampling and test plots were established along the transects at intervals of 440 paces. The frequency of occurrence of each plant species and its density within each plot was recorded. One hundred plots were examined in this manner and a computation of all the plant densities of the vegetation within them gave an average density of .1072. The comparable figure obtained from the study plots worked in 1937 was .0784, an increase of .0288, or 36.7%.

Much of this was due to fast growing weeds such as species of Eriogonum, Balsamorrhiza, Achillea, and Antennaria and also to numerous annuals of inferior forage value that are more rapidly responsive to favorable climatic conditions than some of the better forage plants. *Artemisia frigida* and several species of Chrysothamnus, shrubs of fair forage value, but also indicators of overgrazing, made very abundant growth on the thinly vegetated, overgrazed areas. The different species of Stipa, but particularly *Stipa comata* or porcupine grass, showed the largest gain among the grasses. This species, of fair forage value to elks, is rated very low among the grasses in the order of plant succession, but its increasing appearance on a range which had deteriorated to the extent that its cover consisted largely of weeds and some intruding obnoxious grasses, indicated that the range was on the road to recovery. Wheat grasses made the next largest gains especially in the lower winter range where these grasses once constituted the climax but had more recently been replaced by intruding *Stipa comata* and weed type plants. However, there was also a marked increase in the better forage grasses such as the various species of Poa, Festuca, and Agrostis. A good seed crop of these grasses was produced during the season. Several species of Hordeum (barley grass) and also *Bromus tectorum* (cheat grass) very markedly increased in the lower winter range where partial destruction of the cover had taken place.

These latter grasses are largely obnoxious. *Salsola pestifer* (Russian thistle), which had also gained a strong foothold in the last-mentioned area, was found to be on the decline.

### VOLUME PLOTS

The year to year change in the amount of forage produced on the range is not accurately determined by annually ascertaining the plant density because this method does not fully take into account the varying heights attained by the plant growth in different years. In order to obtain more complete data on the volume of forage produced on the Yellowstone winter range, 16 volume plots, containing 100 square feet each, were located on representative sections (Pl. 23-B). The plants within these plots and adjacent areas of identical dimensions and similar plant composition were clipped in alternating years and the clippings air-dried and weighed. In the following table (4) the results of 1937 are compared to those obtained in 1938.

The forage clipped from these plots in 1938 increased in weight 5,450 grams, or 42.7% more than obtained the previous year. Plots 1, 13, and 14 are on the antelope winter range and it will be noted that these plots showed much less improvement than did the others.

### ASPEN PLOTS

For the purpose of determining the degree of aspen browse utilization by

TABLE 4

| *Plot number* | *Location* | *Major plants* | *Weight of clippings in grams* | |
|---|---|---|---|---|
| | | | *1937* | *1938* |
| 1 | Old Gardiner Road | Koeleria cristata, Artemisia tridentata, Poa species | 255 | 267 |
| 2 | Mt. Everts | Stipa comata, Artemisia frigida, Arabis species | 354 | 547 |
| 3 | Upper Blacktail | Koeleria cristata, Chrysothamnus species, Artemisia frigida | 312 | 632 |
| 4 | Lower Blacktail | Stipa species, Agropyron species, Artemisia frigida | 624 | 846 |
| 5 | Lower slopes Hellroaring | Stipa comata, Agropyron species, Eriogonum species | [1]142 | 548 |
| 6 | Upper slopes Hellroaring | Stipa comata, Poa species, Eriogonum species | 482 | 834 |
| 7 | Horseshoe Lamar River | Stipa comata, Artemisia frigida | 638 | 1,294 |
| 8 | Buffalo Ranch | Chrysothamnus species, Koeleria cristata, Poa species | 624 | 1,024 |
| 9 | Soda Butte | Stipa species, Poa species, Koeleria cristata, Agropyron species, Eriogonum species, Artemisia species | 1,162 | 1,884 |
| 10 | Mammoth | Poa species, Agropyron species, Chrysothamnus species, Artemisia frigida | 510 | 584 |
| 11 | Swan Lake Flat | Stipa species, Danthonia intermedia | 632 | 958 |
| 12 | Glen Creek | Artemisia frigida, Carex species, Poa species | 298 | 364 |
| 13 | Game Ranch Gardiner | Stipa comata, Oryzopsis hymenoides | 624 | 468 |
| 14 | Mt. Everts | Stipa comata, Agropyron species | [1]369 | 421 |
| 15 | Tower Falls | Carex species, Salix (shoots) | 3,487 | 4,002 |
| 16 | Horseshoe (Specimen Ridge) | Elymus condensatus | 2,211 | 3,521 |
| | | Totals | 12,744 | 18,194 |

[1] Grasshopper damage.

game animals, experimental plots 10, 16, and 25 were established on the winter range area. These plots were game proof enclosures 20 feet square. Adjacent to these enclosures, unprotected plots of the same dimensions were employed as check areas (Pl. 20). The aspens within the protected and unprotected plots were inspected annually and where the stand consisted of reproduction, measurements were taken. In this manner a comparative record of year to year changes was obtained.

The death rate during the past year was 50.7% greater among trees in the unprotected, than in the protected, area. While the trees in the protected area gained 20% in height, there was a decrease of 24.2% in the height of the unprotected trees.

In this case the death rate was 1.7% greater among the protected, than among the unprotected, trees. There was an increase in the number of trees in the unprotected area while the protected plot showed a decrease. However, the new trees in the unprotected plot were largely suckers from the roots of trees that had been browsed off in preceding years. The average height increase was 2.9 inches in favor of the trees in the protected plot. Snowdrifts on the unprotected plot also gave the plants thereon a measure of protection that had not been anticipated.

Many of the trees in the unprotected as well as in the protected areas of plots 10 and 16 died from an infestation of aphides, or plant lice, although some of the trees within the protected areas died because of natural competition.

*Plot 10—Old Mammoth-Gardiner Road*
*Established in 1935*

| | *Number of trees* | | | | *Dead trees* | *New trees* | *Change in numbers* |
|---|---|---|---|---|---|---|---|
| | *1935* | *1936* | *1937* | *1938* | *1938* | *1938* | *1938* |
| Protected Area | 187 | 238 | 243 | 219 | 25 or 10.2% | 1 | −9.8% |
| Unprotected Area | 97 | 86 | 82 | 32 | 50 or 60.9% | 0 | −60.9% |

| | *Average height of trees* | | | | *Growth in past year* |
|---|---|---|---|---|---|
| | *1935* | *1936* | *1937* | *1938* | *1938* |
| Protected Area | 15.2″ | 26.1″ | 41.2″ | 51.5″ | 10.3″ |
| Unprotected Area | 13.6″ | 14.3″ | 12.8″ | 10.3″ | −2.5″ |

*Plot 16—Gallatin*
*Established in 1935*

| | *Number of trees* | | | | *Dead trees* | *New trees* | *Change in numbers* |
|---|---|---|---|---|---|---|---|
| | *1935* | *1936* | *1937* | *1938* | *1938* | *1938* | *1938* |
| Protected Area | 102 | 141 | 136 | 104 | 37 or 27.2% | 5 | −23.5% |
| Unprotected Area | 126 | 127 | 90 | 119 | 23 or 25.5% | 52 | 32.2% |

| | *Average height of trees* | | | | *Growth in past year* |
|---|---|---|---|---|---|
| | *1935* | *1936* | *1937* | *1938* | *1938* |
| Protected Area | 15.2″ | 17.2″ | 22.1″ | 25.6″ | 3.5″ |
| Unprotected Area | 13.0″ | 11.5″ | 14.3″ | 14.9″ | 0.6″ |

*Plot 25—Tower Falls*

| | *Number of trees* | | | *Dead trees* | *New trees* | *Change in numbers* |
|---|---|---|---|---|---|---|
| | *1936* | *1937* | *1938* | *1938* | *1938* | *1938* |
| Protected Area | 99 | 114 | 112 | 8 | 6 | −1.6% |
| Unprotected Area | 86 | 80 | 43 | 38 | 1 | −46.2% |

The aspen stand in this plot is nearly mature and therefore no growth measurements were made.

### SUMMARY OF ASPEN PLOT DATA

The average decrease in number of trees from the original stand for the three unprotected areas was 42.7%, while the trees in the protected areas increased by 9.3%. The growth of the reproduction in plots 10 and 16 was also decidedly less in the unprotected portions. The aspen in the unprotected parts of plots 10 and 16 are all but extinct as the remaining trees there are in very poor condition and their unhealthy, chewed-off appearance indicates that they will not survive much longer. It is believed that the trees in the unprotected area of plot 16 would have fared little better had it not been for the sheltering cover of a snowdrift.

The status of the aspen on the winter range in general doubtless is similar to that revealed by the unprotected areas of this experiment. The browsing of aspen to a moderate extent by game animals, entailing the loss of a small percentage of the stand is normal. However, browsing particularly by elks, to the excessive extent that has been shown by study of these plots clearly threatens the existence of aspen on the winter range. (Pl. 21-B)

### CONCLUSIONS

The marked improvement in plant growth that took place during the growing season of 1937 failed to prevent an acute shortage in forage during the following winter on the winter range in Yellowstone Park. This occurred despite a very substantial reduction in the number of elks by hunting, by shipment alive, and by migration beyond the park boundaries of a larger than usual number of the animals.

The forage shortage was clearly indicated by depletion of herbaceous plants and by the abnormally large browse utilization. The number of dead animals that were found on the range during the winter of 1937–38 was also much greater than during the preceding three years and while no doubt a number of these animals died of old age and disease, it can be quite safely assumed that malnutrition was the major cause.

Serious overgrazing occurred in many parts of the winter range and particularly in the important Gardiner area. The adverse influence of overgrazing is responsible at least in part for the lesser improvement of that area as compared with the remainder of the range.

There was marked general improvement in plant growth on the winter range during the summer of 1938. But this recovery, although prevailing for two consecutive growing seasons, must still be considered as being in a primary stage. Many of the plants that represent the increase in vegetative cover are transitory species of small forage value that will be replaced by better

forage plants only after a prolonged process of recovery. There is no assurance, moreover, that the necessary favorable climatic conditions, will continue. Recurrence of drouth before a more permanent cover of good forage plants has been reestablished on the winter range, will very rapidly undo the improvement that has taken place during the last two years.

It is believed that the number 7,334, found to be the average elk carrying capacity of the winter range over the last four years, represents the maximum number that the range in its present condition can sustain. Some damage to the plant cover will be done even by this or perhaps by a lesser number of animals. It should not, however, result in denuding sizeable areas although it probably will bring about a change in composition of the plant cover. This change in the plant climax is believed to be inevitable if large numbers of game animals continue to utilize this range and should not be considered unnatural.

There were 10,838 elks counted on the main body of the winter range in March, 1938. At least 400 of these are known subsequently to have died, hence the number of mature elks that used the winter range in 1938–39 was approximately 10,400 head. This year's calf crop, conservatively estimated, brought the herd up to 12,000. Since the carrying capacity of the range for the average winter was found to be 7,334 elks, it is evident that the area is again heavily overstocked. A reduction in the number of elks must, therefore, be made to prevent serious injury to the range plant cover and needless suffering among the animals. It was not anticipated that the reduction that could be effected during the winter of 1938–39 would bring the herd to the number given as the normal winter range carrying capacity. It was believed, however, that it could be sufficiently large to adjust the elk population to a carrying capacity that may have been increased by favorable climatic conditions, especially if these continue during the next growing season.

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# MICHIGAN COTTONTAILS IN WINTER

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Mearn's cottontail (*Sylvilagus floridanus mearnsii*) is the most numerous and uniformly distributed game animal of southern Michigan. In the open season of 1937 approximately half a million small game hunters killed more than two million cottontails in the State. The clearing of the original forest and the cultivation of fields greatly favored this species and permitted considerable extension of its range. Whereas originally it was restricted to the southernmost counties, at present it is found over the entire lower peninsula (Dice 1927), and there are an increasing number of records from the upper peninsula.

Despite its general occurrence and economic importance, there is comparatively little known of the habits of the species, the factors which determine its numbers, and methods for its practical management. For this reason emphasis has been placed upon rabbit studies by the Michigan Department of Conservation in certain investigations designed to establish a fund of exact information on important wildlife species. The data here presented are the results in part of a research project at the W. K. Kellogg Farm and Bird Sanctuary in Kalamazoo County. The study was continuous from October, 1935 to August, 1937. The area is owned by Michigan State College, which cooperated in the study through M. D. Pirnie, Director of the Kellogg Bird Sanctuary, and C. M. McCrary, Superintendent of the Kellogg Farm.[1] A few data on rabbit hunts are included for the fall of 1934 when preliminary studies were being made under an assistantship at the Kellogg Bird Sanctuary.

The area studied comprises 500 acres of sandy loam in Section 8, Ross Township, Kalamazoo County. Near the center is Wintergreen Lake, a 20-acre pit in the outwash plain upon which the territory lies. This lake is surrounded by the fenced 80 acres of the sanctuary, and the remainder of the tract is occupied by the farm. The sanctuary and portions of the farm immediately to the east and west are rough in topography and uncultivated. Large plantations of pines and spruces aggregating about 5,000 trees were made here in 1927. These, as well as the extensive lowland brush coverts that have been allowed to grow up around the lake and 5 kettle-holes, provide an abundance of excellent winter rabbit cover (Pl. 22-A) and appear to be one of the important factors making the area favorable to the cottontail.

Three principal methods of study were used. Throughout both seasons extensive field work was done regularly over the entire tract. In addition, box traps varying in number from 20 to 70 (Pl. 23) were operated in periods during November and December and continu-

[1] For much help and advice in this project the author is indebted to M. D. Pirnie of the Kellogg Bird Sanctuary; and to H. D. Ruhl, in charge, Paul Hickie, G. W. Bradt, and F. F. Tubbs of the Game Division, Michigan Department of Conservation. Curtis Bartlett of the State Game Farm served as field assistant during two winters.

ously from January 1 through March 31 for a total of 10,676 trap-nights. These traps were placed where tracks and other signs showed rabbits to be most abundant, hence were located almost entirely within brushy coverts. The extent to which this was true can be seen by comparing Plate 22-A with Plate 23. The bait used was ear corn. The third method was controlled shooting, used principally during December.

Rabbits taken in the traps were marked as individuals by tattooing a number in the ear. This was accomplished by dipping a sharp steel pen in black carbon ink and stippling in the number by piercing the skin on the inner surface of the ear. This is a slight modification of a method demonstrated to me by Paul Hickie and used by him in rabbit studies on the Edwin S. George Reserve of the University of Michigan. Each time a rabbit was taken in a trap it was weighed, sexed, and liberated at the place where caught. Weights were taken with a spring field scale having a capacity of 5 pounds (2,268 grams) which could be read accurately to within half an ounce or approximately 14 grams.

The two winters were very dissimilar from the standpoint of weather. The season of 1935–36 was characterized by low temperatures and deep snow, which late in February reached a depth of 26 inches. The winter of 1936–37 was comparatively mild and "open." Only once was there more than 5 inches of snow, and this was in late November. During much of the winter the ground was bare. Evidently these very divergent weather conditions occasioned considerable differences in the behavior of cottontails.

## WEIGHT VARIATIONS IN THE COTTONTAIL

A total of 321 rabbits were weighed during December and January. The weights given are those taken nearest to December 31. The mean in grams for males and females combined was $1,405.37 \pm 9.86$. The mean weight for 153 females was $1,413.24 \pm 14.97$, and that of 168 males was $1,398.21 \pm 13.05$ grams, giving a difference in this series of 15.03 grams between the weights for the two sexes. In every group of rabbits sampled, females averaged heavier than males. This is undoubtedly the natural condition even though the difference in the above series is not statistically significant.

It might seem logical that an adverse winter involving deep snows would tend to reduce the available food supply of rabbits and result in a corresponding decrease in the average weight. As a test of this hypothesis, the weights of 54 rabbits (27 males; 27 females) captured during February and March, 1936 can be compared with the weights of 68 animals (34 males; 34 females) shot in December, 1935. The mean weight of the late winter rabbits was 1,338.1 grams while that for the December animals was 1,386.9 grams. It appears probable that this reduction of 48.8 grams may be ascribed to the period of severe weather through which the late winter rabbits had just passed. The fact that the indicated loss of weight in these animals was no larger, however, speaks well for the ability of the rabbit to maintain its physical condition during a protracted period of deep snow and low temperature. Whether the difference in weight between late fall and late winter was pecu-

liar to this single adverse season or whether a similar loss occurs every winter is not known.

A few juvenile rabbits were handled during the spring and summer of 1936. Of these, three marked individuals were retaken during the following winter. Table 1 gives the weights of these rabbits when first caught and when they were recaptured. It is apparent that these early season juveniles had attained full growth by December, as each weighed considerably more than the average for winter cottontails. The smallest November rabbit recorded (a female) weighed 879 grams. The smallest December animal (a male) weighed 907 grams. Both were obviously late juveniles.

TABLE 1

GAIN IN WEIGHT OF THREE JUVENILE RABBITS

| *Number* | *Date marked* | *Weight (grams)* | *Date recaptured* | *Weight (grams)* |
|---|---|---|---|---|
| 72 ♀ | 4/17/36 | 198 | 12/18/36 | 1,474 |
| 73 ♂ | 6/ 1/36 | 227 | 12/15/36 | 1,559 |
| 78 ♂ | 6/11/36 | 240 | 12/18/36 | 1,488 |
| | Average December weight | | | 1,507 |

Of 70 rabbits marked during January, February, and March, 1936 only 12 were taken again during the following winter. At this time they were known to be (at least) in their second winter. One of these old rabbits was first recovered in November, 10 were taken in December, and one in February. Ten of these were weighed and averaged 1,618.8 grams. Of these, 6 were females and 4 were males. There appears to be little doubt that the heavier, more massive individuals usually found in a large kill are old rabbits. The heaviest weight recorded for a rabbit in this study was 1,899 grams. This animal was a female. Only four rabbits weighed over 1,800 grams and of these only one was a male.

## WINTER FOODS

Several authors give information on the food habits of cottontails. Todd (1927), working near Syracuse, New York, listed 71 species of plants that were eaten by the rabbit in winter. Of these only one species was herbaceous. Seton (1909) observes that "To make a complete list of the plants that serve the Cottontails as food, would mean a catalog of 99 per cent. of the flora of the United States." Kennicott (1857) gave among their winter food plants " . . . the buds and young shoots of briars, sumach, hazel, thorn, oak, hickory, basswood, poplar, and other shrubs and trees."

Among winter foods of rabbits at the Kellogg Farm, one herbaceous species, buckhorn, or lance-leaved plantain (*Plantago lanceolata*), was used above all others. It was very abundant where pasturing by geese on the sanctuary had removed nearly all the grass among the pine plantings, and it appeared to be a staple food when snow was not deep. In November, 1936 a rabbit picked up on the road a mile from the farm had a large leaf of this herb grasped by the base in its front teeth. Often in early winter there was good evidence that rabbits were digging through an inch of snow to get at the plantain. Yarrow (*Achillea millefolium*) also was obtained in this way. Kennicott (1857) says that the rabbit does not " . . . generally, if ever, dig through the snow for food." The habit certainly is not developed to the extent that it is in squirrels, but it was not uncommon

to find evidences of digging around the pine areas on the sanctuary when the snow was not more than an inch deep. In one instance a rabbit appeared to have fed where a muskrat had been digging for plantain.

A field of soy beans was extensively used by rabbits in the winter of 1935–36. Both pods and foliage were taken in large quantities. The rabbits living in stump piles in near-by gullies made regular nocturnal visits to this adjacent field.

Under conditions of deep snow the bark and twigs of woody plants seemed to be the principal source of food for cottontails. In Table 2 is given a list of the woody plants that were observed to be taken in the first winter and the comparative extent of their use as judged by field observations. It is to be remembered that this list does not in every case represent the extent of the rabbits' preference for a particular food. The amount of some food plants taken was small evidently because there were but few of them on the area. The species to which this comment appears particularly to apply are apple, ailanthus, wild crab, and buckthorn.

The only plants that were observed to be pruned by rabbits were apple, raspberry, black oak, and white spruce. In all others bark was gnawed from the

TABLE 2

WOODY PLANTS USED AS FOOD BY RABBITS IN WINTER 1935–36

| Species | Extent of use | | |
|---|---|---|---|
| | Large | Moderate | Little |
| Dwarf sumac (*Rhus copallina*) 1[1] | x | | |
| Staghorn sumac (*Rhus typhina*) 1 | x | | |
| Smooth sumac (*Rhus glabra*) 3 | | | x |
| Sandbar willow (*Salix longifolia*) 1 | | x | |
| Red oak (*Quercus borealis maxima*) 3 | | | x |
| Black oak (*Quercus velutina*) 2 | | | x |
| Sassafras (*Sassafras officinale*) 1 | | x | |
| Ailanthus (*Ailanthus glandulosa*) 3 | | | x |
| Pignut hickory (*Carya glabra*) 3 | | | x |
| Wild crab (*Pyrus coronaria*) 3 | | | x |
| Cultivated apple (*Pyrus malus*) 3 | | x | |
| Buckthorn (*Rhamnus cathartica*) 3 | | x | |
| Wild black cherry (*Prunus serotina*) 2 | | x | |
| Gray dogwood (*Cornus candidissima*) 1 | | x | |
| Silky dogwood (*Cornus amomum*) 1 | | x | |
| Red-osier dogwood (*Cornus stolonifera*) 1 | | | x |
| Buttonbush (*Cephalanthus occidentalis*) 1 | | | x |
| Black elder (*Sambucus canadensis*) 1 | | x | |
| Bush rose (*Rosa* sp.) 2 | | | x |
| Fox grape (*Vitis vulpina*) 2 | | x | |
| Black raspberry (*Rubus occidentalis*) 2 | | x | |
| Red raspberry (*Rubus strigosus*) 1 | | | x |
| Blackberry (*Rubus allegheniensis*) 1 | | | x |
| Dewberry (*Rubus procumbens*) 1 | | | x |
| Hawthorn (*Crataegus* sp.) 3 | | | x |
| White spruce (*Picea canadensis*) 2 | | | x |
| Jack pine (*Pinus banksiana*) 2 | | | x |
| Scotch pine (*Pinus sylvestris*) 2 | | x | |
| Red pine (*Pinus resinosa*) 3 | | | x |

[1] Key: 1 = abundant. 2 = common. 3 = less common.

twigs. During February, 1936 the snow was so deep that in a near-by apple orchard rabbits were able to reach the lower limbs and twigs of the trees. The bark was taken from small branches and twigs less than ½ inch in diameter, but the larger limbs and trunks were not damaged. In a few cases the ends of twigs were eaten, but most of the pruning was restricted to shoots around the trunks.

Of all woody plants, dwarf and staghorn sumac were eaten most often. In late winter of 1936 there were few patches of dwarf sumac that did not show extensive use by rabbits. Where this plant was absent staghorn sumac appeared to be a satisfactory substitute. Around some kettle-holes on adjacent farms most sumac stems were almost completely bare as high as a rabbit could reach. Hendrickson (1938) found that in Iowa smooth sumac (*Rhus glabra*) was a preferred food. In general, sumacs are of little value as cover, but they are significant on the area discussed as the most important food of rabbits under conditions of deep snow.

From two winters' observation it appears that the amount of bark eaten by rabbits depends to a great extent upon the quantity of herbaceous foods that are available. The list of woody foods was made entirely in the winter of 1935–36. In the winter of 1936–37, although some dwarf sumac was taken as early as the first of November, the amounts of bark eaten were negligible, and it was exceptional to find a freshly gnawed stem after the first of January. From this it appears that herbaceous foods are preferred.

In the first winter of the work, grain was eaten by rabbits whenever it was available. Corn shocks in a field east of the area were used as shelter in early winter and low-hanging ears were stripped of their kernels. Feeding stations put out for birds were regularly patronized also by cottontails. Similar observations were made by Hawkins (1937) in Wisconsin. That author has reason to believe that in his region little grain is taken where browse is available. At the Kellogg Farm, ear corn and other grains were consumed in the midst of what apparently was acceptable browse. No widespread feeding of grains, however, was practiced.

### USE OF COVER

It is only in winter that adequate cover becomes a problem for rabbits in this region. Nearly any thick vegetation, herbaceous or otherwise, is likely to be used during the summer season. Hay fields were frequented, while small brush and coniferous coverts interspersed with open areas were a preferred combination.

One of the natural coverts on the Kellogg Farm that appeared to be most favored by rabbits in fall and winter was a cut-over oak and hickory brush area on the north side. This thick tangle of black oak (*Quercus velutina*), pignut hickory (*Carya glabra*), dwarf sumac (*Rhus copallina*), sassafras (*Sassafras officinale*), hawthorn (*Crataegus* sp.), red raspberry (*Rubus strigosus*), blackberry (*Rubus allegheniensis*), rose (*Rosa* sp.), grape (*Vitis vulpina*), and other woody plants created a habitat providing both cover and food. The 5-acre plot contained a large number of old skunk and woodchuck burrows that were intensively used by the rabbits.

When snow was on the ground, the area was often a maze of tracks. From all appearances this is the natural upland winter cover type most favorable to rabbits in this region.

In the lowland brush thickets around the lake and swales the most numerous cover plants were dogwood (*Cornus stolonifera*, *C. amomum*, and *C. candidissima*), buttonbush (*Cephalanthus occidentalis*), and willow (*Salix longifolia*). This form of natural brush was the most widely distributed cover on the area and in places contained muskrat or skunk holes which were used by the rabbits. The frozen marshes adjacent to these coverts, with such herbaceous species as sedge (*Carex* sp.) and cattail (*Typha latifolia*), were attractive as places to "bed out" in forms above ground. This combination is an extensive cover type in some portions of southern Michigan and is of utmost importance to the cottontail population.

The stands of young conifers on the sanctuary and farm appeared to form ideal winter cover for rabbits. Their value is unimpaired by any depth of snow occurring in this region. From five to ten rabbits were not uncommonly driven from plantations of an acre or two on the sanctuary. The fact that these pines and spruces produce but little food did not appear to hinder their use either in winter or summer. Our observations under a variety of conditions indicate that ground holes are not necessary for conifers to function effectively as rabbit cover in winter. The forms were located among the low-hanging branches and became almost the equivalent of burrows as the snow increased in depth. White pine (*Pinus strobus*), Scotch pine (*P. sylvestris*), red pine (*P. resinosa*), jackpine (*P. banksiana*), and white spruce (*Picea canadensis*) were the species most commonly found on this area. When pines are planted in thick stands they are most effective as cover up to about ten years old. After this the lower limbs die and the stand becomes too open underneath to provide ground cover. Scattered clumps hold their lower branches and make good cover for a much longer period.

Underground cover was much used by rabbits on the Kellogg Farm. During the winter of 1935–36, burrows in the open fields were deep under the snow and were not often used by this species. Those in the coverts, however, were kept open. In the following winter, when conditions were favorable for tracking, burrows along fence rows and in fields were frequently found with rabbit tracks leading into them. Several washes on the farm, which had been filled with stumps to check erosion, appeared to be the headquarters for whole colonies of rabbits in the winter when snow was deep. When snow melted in late February, however, the animals largely disappeared from such cover. One gully that was being filled with refuse of every kind was the abiding place of many rabbits as well as of rats and skunks. Hollow logs and holes under buildings, stumps, and the bases of trees were at times found to serve as winter cover for this species in the vicinity studied.

The passage of rabbits through cover is facilitated by well-defined paths. The manner of establishing these paths was easily followed on fresh snow. Wherever a rabbit travels, whether

through cover or in the open, it usually follows the track of another rabbit, if any be present, or retraces its own track. Many times rabbits were observed to run from one cover patch to another and to return by the same route. In this manner well-beaten trails are soon established after every fall of snow.

### ACTIVITY

Nearly anyone who has driven a car at night will attest to the fact that rabbits are abroad at that time. It is then that most of the mortality on highways occurs. On many occasions traps were run in the afternoon at the Kellogg Farm. In a few cases rabbits were caught, especially if it was late in the day. The number was small, however, compared with those taken at night. The greatest daytime activity was observed in spring when the sexual urge appeared to be the cause. At dusk and just before sunrise were the hours when most rabbits were observed. Presumably the animals at these times were beginning and terminating the night's activity.

There is evidence also that weather to some extent conditions the activity of cottontails. M. B. Trautman in Ohio (Trippensee 1934) found that, when snow was on the ground, the use of holes by rabbits was greatly increased if the temperature fell below 20° Fahrenheit. He found also that females were more prone to hole up than males. Of 391 rabbits taken from holes with a ferret, 230 were females and 161 were males (58 percent females: 42 percent males). Gerstell (1937) in Pennsylvania obtained even more striking results. On three consecutive days 878 rabbits taken by gunners were sexed. Of these, 694 (79 percent) were males and 184 (21 percent) were females. The author states, "Due to casual observations and discussions the writer is inclined to believe that during the fall and early winter months in Pennsylvania, it is entirely possible that the great majority of rabbits found in their 'forms' during the daylight hours are males of the species and that the vast percentage of the females remain 'holed up' under the same conditions, emerging from the dens to play and forage only after dark."

Leopold (1931) has indicated that there is probably a "holing up zone," and that the habit is not necessarily a matter of temperature throughout the entire range of the species. In support of this he cites the observed difference in the habits of cottontails in different parts of their range. In Wisconsin rabbits hole up in response to severe winter weather, and hunting under such conditions, even in good rabbit territory, may produce little, showing that few animals are above ground. In Missouri, however, rabbits will be found in their forms during the coldest winter weather. Two observers in northwestern Iowa and southeastern South Dakota have reported that rabbits may remain above ground when the temperature is −10° Fahrenheit, greatly in contrast to the Wisconsin condition where animals will be holed up at +10°. All of Michigan lies north of Leopold's hypothetical line delineating a possible southern limit of the "holing up zone" and the northern boundary of the "bedding out zone." The intensive work at the Kellogg Farm should indicate the habits of cottontails in this region. Data on hunts during three fall seasons are given in

Tables 4, 5, and 6. Several of these hunts are of particular interest.

On December 7, 1934, five men hunted for about 2½ hours and killed 14 rabbits. About 25 were seen. A fresh fall of snow made tracking easy. The temperature during the morning hunt was near +12° Fahrenheit. Many ground holes had tracks leading into them and rabbits were also started from forms above ground. The sex ratio of 11 males to 3 females might indicate that a larger proportion of females were holed up under these conditions.

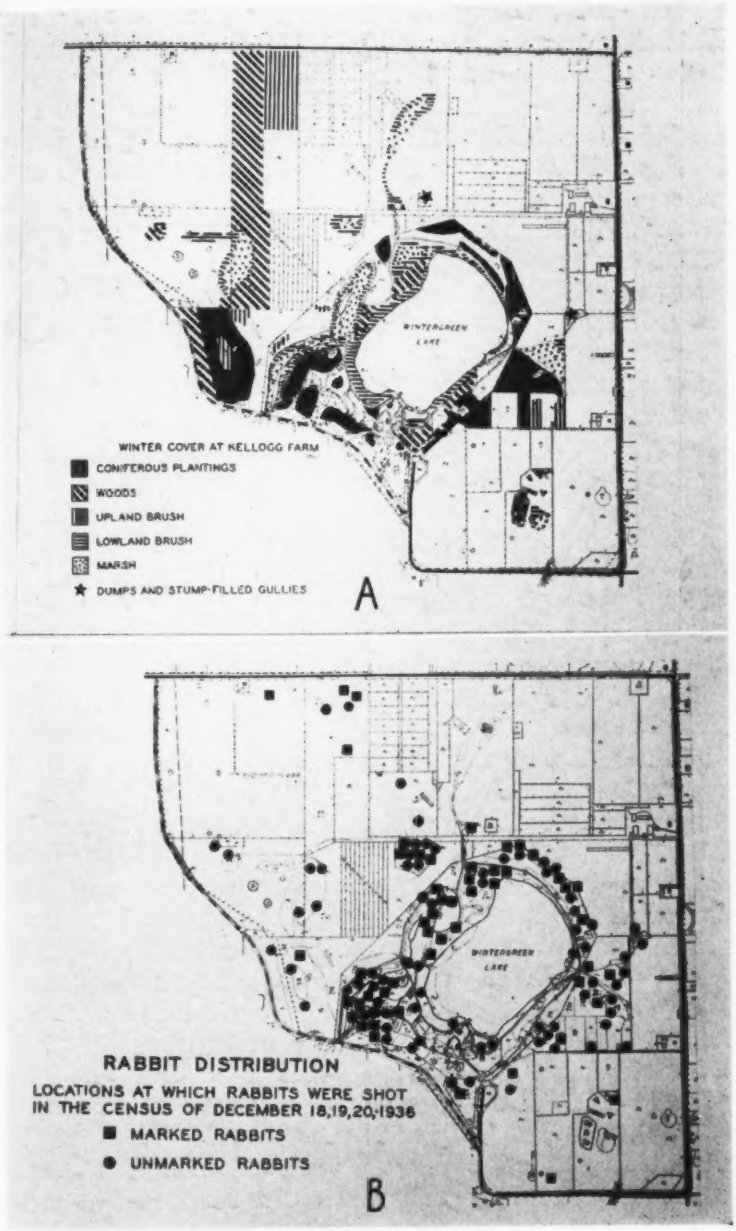
One of the best examples of a hunt under severe weather conditions is that of December 20, 1935. In this hunt the entire area was traversed by a party numbering 4 in the morning and 9 in the afternoon. The minimum temperature of the morning was +7°. At 5:00 P.M. it was +10°. The sky was nearly clear, the wind was strong from the northeast, and the snow was drifting. The effect was that of a very cold day. Rabbits were definitely inactive and very difficult to start, it being necessary in many cases nearly to step on an animal before it left its form. Tracks showed that in the morning many rabbits were holed up in dumps, stump piles, and dens. Relatively few rabbits were seen until in the afternoon when the hunting party reached the oak-hickory brush area on the north side of the farm. This plot, as previously mentioned, contained an abundance of ground holes as well as good cover above ground. More than 20 rabbits were driven into one corner of the tract and 17 were shot. The ground holes evidently were not being intensively used at that time, although tracks showed that they had been used recently. Of 22 rabbits taken during the day 12 were males and 10 were females.

On the following day, December 21, the temperature at 5:00 P.M. was +15°. The sky was cloudy and there was a strong northwest wind. Ten men hunted in the morning and five in the afternoon. Conditions were much as on the previous day. In the morning 12 rabbits were shot and 8 were taken in the afternoon. In this kill 12 were males and 8 were females. Thus in the two days' hunting, with the temperature consistently below +20° and with 5½ inches of snow on the ground, in a total kill of 42 rabbits, 24 were males and 18 were females.

On December 24, 1935, with the temperature +20° at 5:00 P.M. 10 male and 5 female rabbits were shot. However, under even more severe conditions on December 28, 1935, nine females and 7 males were shot. In 1936 on December 20 the shooting was done in the morning when the temperature was near 24°. A light snow was falling. In the kill of 25 rabbits 16 were males and 9 were females.

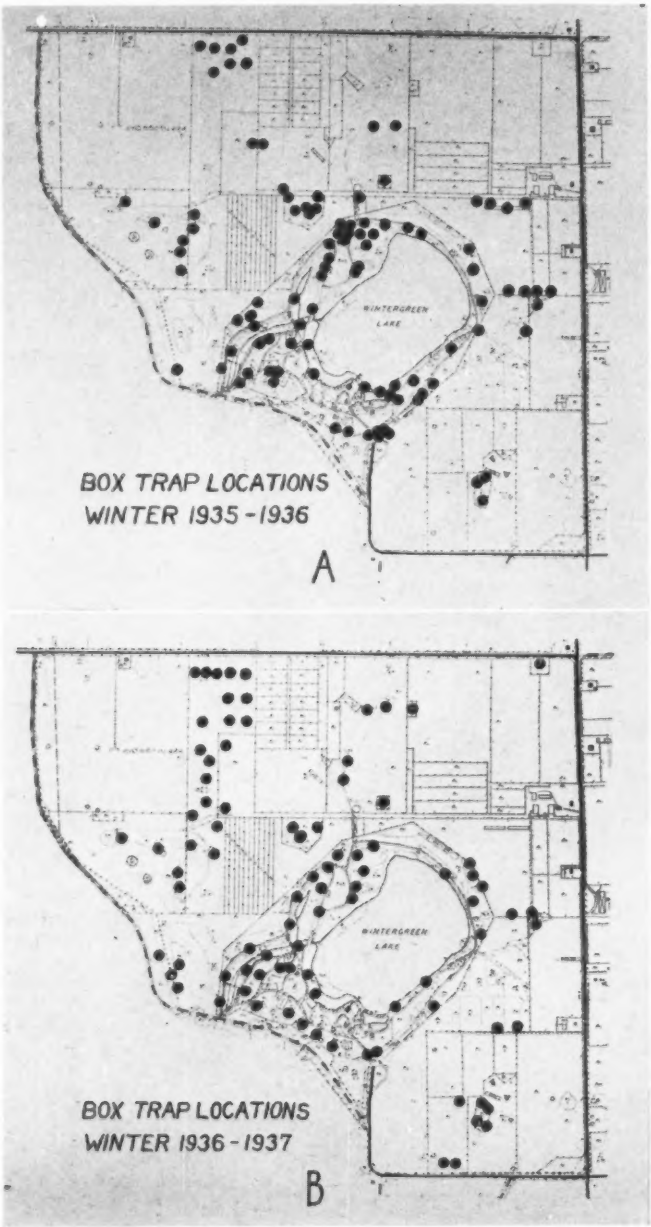
The sex ratio among rabbits on the Kellogg Farm was near 49% females to 51% males (Allen 1938b). This computation is based upon a series of 383 animals taken by all methods. The sexes of 93 rabbits taken in box traps were recorded in the fall of 1936 before any hunting was done. Of these, 48 were males and 45 females, giving a ratio of 48.3% females to 51.7% males. Evidently there was no significant differential between the two sexes in susceptibility to trapping. Table 3 compares the sex ratio in the fall kill[2] of

[2] The actual kill numbered 154. Some of the rabbits were killed by farm hands and were not examined for sex. Such animals could not be included in this comparison.



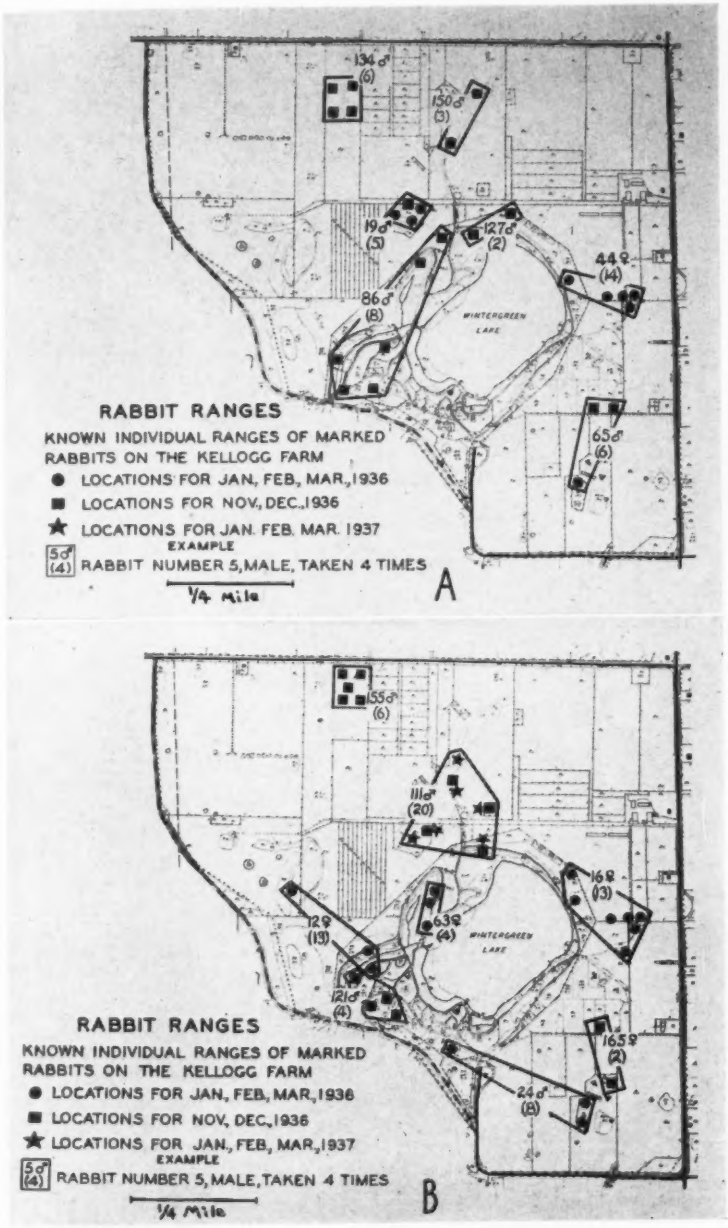

A. (*Upper*)—Principal types of winter rabbit cover on the Kellogg Farm.

B. (*Lower*)—Locations at which 126 rabbits were killed in December, 1936, showing the concentration into cover at this season.

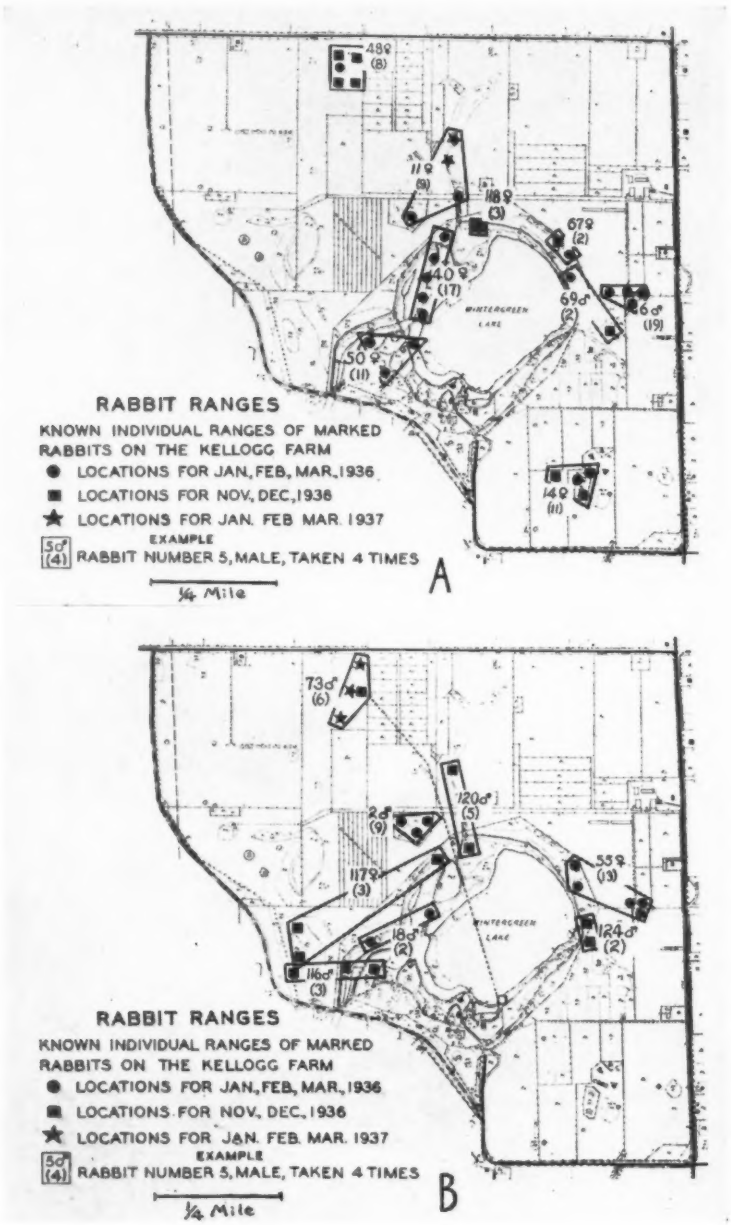



A. (*Upper*)—Locations at which box traps were set during January, February, and March, 1936.

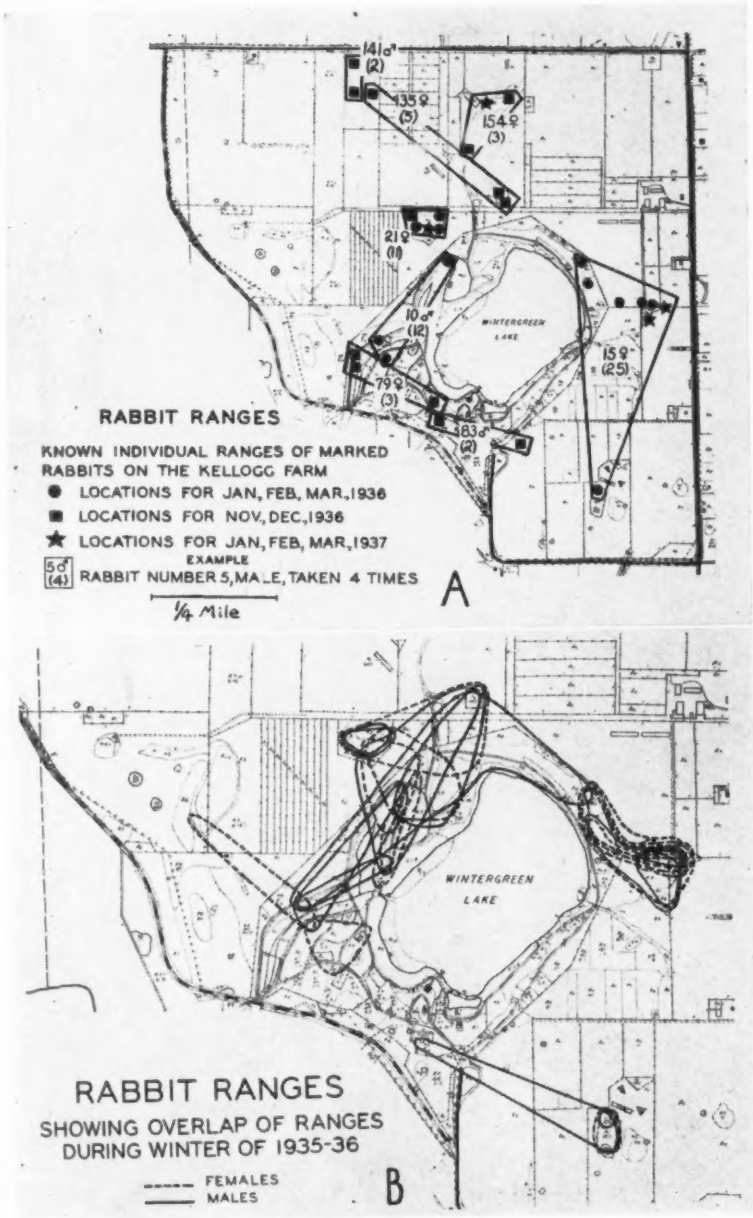
B. (*Lower*)—Locations at which trapping was done in the second fall and winter of the work.




A. (*Upper*)
B. (*Lower*)




A. (*Upper*)
B. (*Lower*)




A. (*Upper*)
B. (*Lower*)

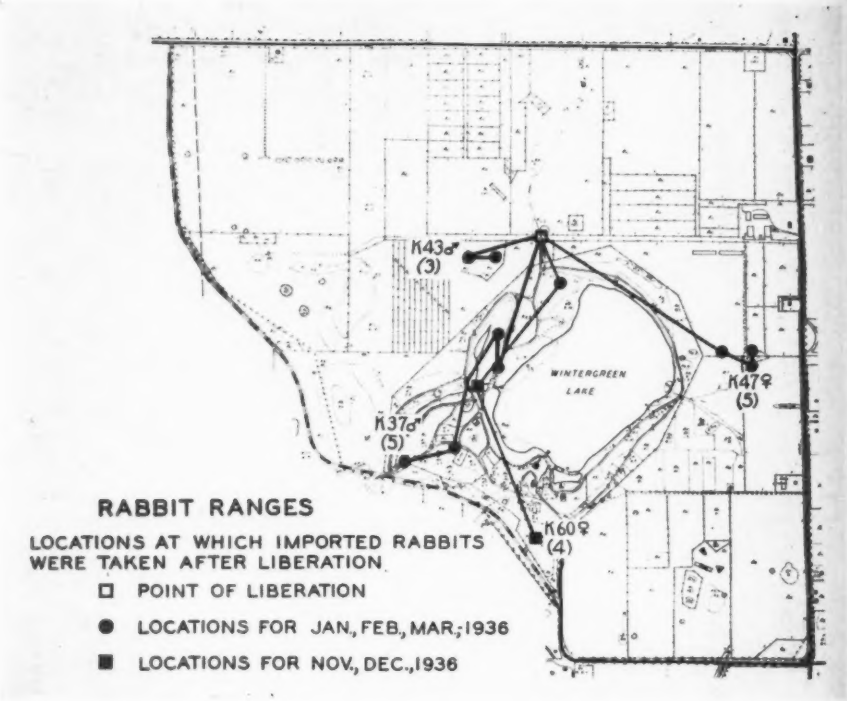

K43♂
(3)
WINTERGREEN
LAKE
K47♀
(5)
K37♂
(5)
K60♀
(4)
RABBIT RANGES
LOCATIONS AT WHICH IMPORTED RABBITS
WERE TAKEN AFTER LIBERATION
□ POINT OF LIBERATION
● LOCATIONS FOR JAN., FEB., MAR., 1936
■ LOCATIONS FOR NOV., DEC., 1936

TABLE 3
SEX RATIO IN THE RABBIT POPULATION OF 1935–36

| Sex | Shot (December) | | Trapped (January–March) | | Total | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Males | 71 | 56 | 28 | 40.6 | 99 | 50.5 |
| Females | 56 | 44 | 41 | 59.4 | 97 | 49.5 |
| Totals | 127 | 100 | 69 | 100 | 196 | 100 |

1935 with the ratio in the series of rabbits handled in the traps during the first 3 months of 1936. The latter animals were what remained of the population after the shooting. The work was very intensive and it is not likely that a very large number of rabbits escaped handling. It is evident that the preponderance of males in the kill was almost exactly compensated for by a corresponding prevalence of females over males in the residual population.

From this comparison and the summarized data on hunts it is evident that there was a tendency for more males than females to be shot under severe weather conditions. This is probably due, as judged from the results of investigators elsewhere, to differential use of burrows by the two sexes. That the tendency was not always manifested in proportion to the severity of the weather and sometimes did not appear at all seems to indicate that the habit may not be so strongly developed in this region as in some others; or that undetermined factors may, at times, effect a modification of behavior.

TABLE 4
RESULTS OF RABBIT HUNTS, 1934

| Date | Temperature 5:00 P.M. (degrees Fahrenheit) | Snow on ground (inches) | Kill | | |
|---|---|---|---|---|---|
| | | | Males | Females | Total |
| Nov. 12 | 34 | 0 | 2 | 4 | 6 |
| Nov. 16 | 51 | 0 | 5 | 1 | 6 |
| Nov. 21 | 61 | 0 | 4 | 2 | 6 |
| Nov. 24 | 35 | 0 | 3 | 0 | 3 |
| Dec. 1 | 31 | 0 | 0 | 1 | 1 |
| Dec. 2 | 30 | 0 | 1 | 1 | 2 |
| Dec. 3 | 34 | Trace | 0 | 3 | 3 |
| Dec. 4 | 30 | .5 | 0 | 6 | 6 |
| Dec. 7 | 20 | 5 | 11 | 3 | 14 |
| Dec. 8 | 23 | 5 | 1 | 2 | 3 |
| Dec. 10 | 14 | 5.5 | 3 | 3 | 6 |
| Dec. 15 | 32 | 4 | 1 | 1 | 2 |
| Dec. 20 | 23 | 6 | 0 | 1 | 1 |
| Dec. 21 | 33 | 9 | 0 | 1 | 1 |
| | | | 31 | 29 | 60 |

Sex ratio—48.3% females: 51.7% males.

TABLE 5

RESULTS OF RABBIT HUNTS, 1935

| Date | Temperature 5:00 P.M. (degrees Fahrenheit) | Snow on ground (inches) | Kill | | |
|---|---|---|---|---|---|
| | | | Males | Females | Total |
| Dec. 5 | 31 | 1 | 20 | 14 | 34 |
| Dec. 6 | 34 | 1 | 2 | 1 | 3 |
| Dec. 16 | 31 | 4 | 3 | 6 | 9 |
| Dec. 20 | 10 | 5.5 | 12 | 10 | 22 |
| Dec. 21 | 15 | 5.5 | 12 | 8 | 20 |
| Dec. 24 | 20 | 5.5 | 10 | 5 | 15 |
| Dec. 26 | 14 | 11.5 | 1 | 0 | 1 |
| Dec. 27 | 18 | 12.5 | 1 | 0 | 1 |
| Dec. 28 | 5 | 12.5 | 7 | 9 | 16 |
| Dec. 30 | 26 | 12.5 | 3 | 3 | 6 |
| | | | 71 | 56 | 127 |

Sex ratio—44% females: 56% males.

TABLE 6

RESULTS OF RABBIT HUNTS, 1936

| Date | Temperature 5:00 P.M. (degrees Fahrenheit) | Snow on ground (inches) | Kill | | |
|---|---|---|---|---|---|
| | | | Males | Females | Total |
| Dec. 18 | 26 | 0 | 24 | 25 | 49 |
| Dec. 19 | 24 | 1 | 26 | 24 | 50 |
| Dec. 20 | 29 | 3 | 16 | 9 | 25 |
| | | | 66 | 58 | 124 |

Sex ratio—46.7% females: 53.3% males.

## SEASONAL MOVEMENTS

In late fall, as frosts killed down the annual vegetation, fewer rabbits were found in the open fields and there was a very apparent concentration in patches of dense brush and coniferous cover. In the fall of 1936 all the rabbit hunting was done in three days: December 18, 19, and 20. In these hunts the location where each rabbit was shot was recorded on a map in the field. In Plate 22-B are given the locations for the entire kill. A comparison of this map with Plate 22-A will show that nearly all of the animals shot were taken in brush or coniferous plantations. As the hunting was done wherever tracks showed that rabbits were present, this map appears to illustrate the true distribution of rabbits on the farm at the time. Although comparable records are not available for 1935, observations in the field indicated that conditions during the two fall seasons were similar.

The distribution of rabbits during the remainder of the winter, however, varied markedly with the two seasons. In the first winter, when deep snows persisted until late February, rabbits continued to be taken in the traps in numbers until the snow melted. The percentage of traps filled varied directly with the depth of snow on the ground (Allen 1938a) and averaged more than 20 percent in mid-February at the time of maximum depth. During the

second winter, when the ground was seldom covered with snow, a more general distribution of rabbits was observed as early as the end of December. The number of successful trap-nights in the brush coverts seldom ran over 2 or 3 percent for any ten-day period during the winter months—a condition that was not reached until March of the year before. A part of the difference in trap success probably is due to the scarcity of food during the time of deep snow. It is logical that this would make the trap bait more attractive. However, when tracking was possible in 1937, there were abundant signs to show that outlying burrows in the fields and fence rows that had been sealed in the winter before were being used by rabbits. Tracks around such former concentration points as stump piles and dumps were much less noticeable during the second winter. These observations bear out the logical expectation that rabbits are more concentrated during a season of deep snow than in an "open" winter, and that under the latter conditions the land has a greater carrying capacity.

### HOME RANGE IN WINTER

The data on individual range are based principally upon three trapping periods. In the first three months of 1936 a total of 63 rabbits (including 3 from December) were marked. Seven other individuals were brought in from the section to the west and liberated, as an experiment, at a point near the center of the area. The marked rabbits repeated 366 times in this trapping period. The second period was from November 1 to December 17, 1936. During this time 102 individuals were handled, including 8 from the winter before. There were 96 repeats. The third trapping period was in January, February, and March, 1937. As was previously pointed out, trap success was low due, evidently, to the lack of snow and the consequent wide distribution of rabbits. Only 12 new animals were trapped and only 94 repeat records were obtained.

Range areas were calculated for the first two trapping periods. Only those rabbits are included upon which sufficient information was available to justify some conclusions as to individual ranges. Most animals taken only once or twice, or rabbits caught in only one or two traps were ignored. Range areas were obtained by plotting on a map the locations at which a given rabbit was taken and connecting the outside points with straight lines. The enclosed area was considered to be the "known range." The method has patent weaknesses. Even though a rabbit had a very extensive range, if it were taken at points approximating a straight line, the actual area indicated by a planimeter reading would be very small. To compensate somewhat for this distortion of fact the longest distance across the known range as measured on a straight line was calculated also. For want of a better term this is called the "range diameter." A much better idea of the area occupied by each animal is obtained by considering both of these figures. The data on range would be much more significant had the traps been placed in a geometrical pattern instead of being irregularly spaced in the brush coverts.

The range areas for the first three months of 1936 were considered separately from those of the fall of 1936.

Females were averaged separately from males. The division of the data into these classes together with the limitations of the technique render the number of records in any one class too few for the average to be of great significance. Table 7 gives the summarized range records for the two seasons.

TABLE 7
RANGE DATA FOR FALL AND WINTER COTTONTAILS

| Period | Sex | Individuals | Times taken | | | Known range in acres | | | Range diameter in yards | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Maximum | Minimum | Average | Maximum | Minimum | Average | Maximum | Minimum | Average |
| Jan., Feb., Mar., 1936 | M | 17 | 30 | 2 | 9.7 | 11.63 | .28 | 3.62 | 805 | 92 | 336.4 |
| | F | 19 | 23 | 2 | 11.5 | 7.71 | .26 | 2.22 | 528 | 43 | 237 |
| Nov., Dec., 1936 | M | 26 | 19 | 2 | 3.84 | 10.25 | * | * | 739 | 61 | 259.7 |
| | F | 17 | 8 | 2 | 3.1 | 11.82 | * | * | 756 | 33 | 235.5 |

* Due to the small number of repeats by individuals, ranges could not be calculated for the majority of the fall rabbits and the averages are not significant.

The larger ranges obtained by this method are obviously more significant than the smaller ones. Since the true range will in most cases be larger than the known range, the means in these limited series are considered to be undependable as expressions of the size of the area actually occupied. Rather they must be taken as minimum figures. From these indications, however, it appears that most of the rabbits of the Kellogg farm had winter ranges varying between five and ten acres.

A better conception of the scope of activity of the animals is obtained by an examination of the maps in Plates 24–26 in which the records on 40 cottontails are given. In each case the number of the rabbit in the marked series (1 to 181) is given with the sex[3] and the number of times the rabbit was taken. The locations at which the rabbits were caught are designated by a different symbol for each trapping period. The points are included also at which animals were caught in holes, or by chance methods, or shot.

A study of these maps with relation to the cover (Pl. 22-A) reveals facts of importance regarding the adjustment of the rabbit population to the environment. It was invariably the case where a rabbit survived to a second winter season (or, in two cases, to a third) that it occupied the same approximate range as in the previous year. Thus we may infer that most adults were established in particular areas with which they were familiar and which, once established, they preferred to other, and perhaps even more favorable, parts of the tract. Certain locations apparently

[3] In field records, particularly trapping sheets, an original catch was designated by the letter R written with the number and sex of the rabbit—thus: R14 ♂. In all recaptures the rabbit would be identified as a repeat by the symbol Rr14 ♂.

were very favorable and some rabbits occupied these almost exclusively, seldom wandering far from the choice coverts. As examples, rabbits 19 (Pl. 24-A), 2 (Pl. 25-B), and 21 (Pl. 26-A) occupied the brushy periphery of a small kettle-hole and were never found elsewhere. Rabbits 44, 16, 6, and 55 lived in a "dump" filled with debris which provided an underground maze not far from a pine plantation. This combination was very attractive and a colony of rabbits lived there during the winter of deep snow. Rabbits from the dump habitually followed a fence row a hundred yards west to the pines but apparently seldom ventured very far into the pines or along the brushy lake margin. Rabbits in such areas as this appeared to find all their life necessities within a relatively small area—from two to five acres in some cases. Other animals probably were not so well favored, as they moved about over a much larger territory and appeared to be not so well established. These animals sometimes visited the more favorable locations but did not stay. The impression remains that the best cover on the Kellogg farm was occupied to capacity and that these locations were capable of harboring aggregations of rabbits within a relatively small space. Where a rabbit occupied the seemingly less favorable coverts, it evidently required more territory and appeared to shuttle about over an area often 10 acres or more in extent. Plate 26-B presents all of the idealized ranges that could be conveniently drawn on this map. It serves to illustrate the relationships just discussed.

One rabbit marked as a juvenile on June 1, 1936 was recovered in the following January. In Plate 25-B the unshaded square indicates where this animal was captured and marked when only a few weeks of age. In the winter following it had moved three-quarters of a mile to the northwest and taken up its abode in the oak-hickory brush area. Dalke and Sime (1938) found four rabbits from one to more than two miles from the places where they were tagged as juveniles. Evidently there is a significant "shuffle" among young rabbits.

From a study of Plate 26-B it is quite apparent that there was no effective "territorial" segregation either between animals of the same sex or between the sexes during the season represented.

In February and March, 1936, seven rabbits caught in the section to the west were liberated near the center of the Kellogg farm to afford an opportunity for study of their movements. Three of these animals were never retaken. Four were subsequently captured at the points indicated in Plate 27. Only one of the rabbits remained near the point of liberation. There is evidence that at least two of them (43 and 47) found, and became localized in, good coverts. The other two appeared to wander.

## DISEASE

The most important malady observed among the rabbits was due to a pus-forming bacterium, *Staphylococcus albus*, that affected their eyes. During the first three months of 1936 the incidence of infection was 12% (9 of 70 animals). The affected rabbits exhibited an acute conjunctivitis, which in at least three cases progressed to the destruction of the eye and the death of the animal. In most instances the disease appeared to be chronic and prob-

ably many animals recovered. Two of the rabbits taken in the traps were blind in one eye—a condition that might have resulted from a previous infection of this nature.

According to Don R. Coburn,[4] who diagnosed the illness, infection began in the nasal passages and spread to the eye through the lacrymal duct. Two rabbits died of the infection while being held for observation, and evidence is good that at least one of the trapped rabbits died in the wild. The history of this case is: From December 31 to February 14 rabbit number 3 ♀ was caught 14 times, and the weight averaged about 1,450 grams (3 lbs., 3.1 oz.). On February 14 the eyes were observed to be inflamed, and from this time on the animal steadily lost weight. Until February 25 the rabbit was taken ten more times and on that day the weight was 1,020 grams (2 lbs., 4 oz.). The inflammation had destroyed the eye and the surrounding tissue was a mass of pus. Hair was lacking on the side of the nose where the discharge had run. When liberated, this animal was so ill that it appeared to move with difficulty. It was never caught again. It is interesting to note that its range was very restricted. Among the few rabbits taken in the winter of 1937 no eye infections were observed.

In the course of the work several rabbits were found with superficial skin tumors on the head or the feet. None of these, however, appeared to be prejudicial to the animals' well-being. The only other afflictions, aside from scratches, recorded for the trapped animals were two cases of injury. In one rabbit a sharp splinter of wood deeply inbedded in the groin had resulted in a running sore, and another animal had lost a fore foot.

[4] Then Game Division pathologist of the Department of Conservation; now with the U. S. Biological Survey.

## LONGEVITY

As to the length of life of cottontails, Seton (1909) states, "Probably 6 or 7 years is the limit of age that is attained." Of 70 rabbits marked in this study during the first 3 months of 1936, only 12 are known to have lived to the following November. Ten survived to the December shooting, and 5 of these were still alive after January 1. Thus only 7.1 per cent of this winter population is known to have lived more than a year, in spite of the fact that 171 of a calculated population of 226 rabbits (Allen 1938a) were handled during the second season. These surviving animals would be approximately 1½ years old. Two rabbits are known to have lived to an age of approximately 2½ years. One was taken in December, 1937 and the other in January, 1938. For these records I am indebted to Don A. Switzenberg, who continued work for the Game Division on the tract in the winter of 1937–38.

Where shooting is as intensive as it is on this area, the chances are small that a rabbit will live for more than three years, and certainly very few attain that age under present conditions at the Kellogg farm. This is not particularly surprising, however, as a normally short life would be expected in a species so highly fecund as the cottontail.

## SUMMARY

A two-year study of the cottontail rabbit was carried out on a 500-acre area of farmland in Kalamazoo County,

Michigan. The animals were taken alive in box traps baited with ear corn and marked as individuals by tattooing a number in the ear. In a series of 321 rabbits trapped during December and January the average weight was 1,405.37 grams. The 153 females had a mean weight of 1,413.24 and the 168 males, 1,398.21 grams. A series of rabbits taken at the end of a winter of deep snow and low temperature averaged 48.8 grams less than a corresponding series taken the previous December. Juvenile rabbits born early in the breeding season attained full growth by December. Rabbits known to be approximately 1½ years old were distinctly heavier than young of the year. The heaviest rabbit recorded weighed 1,899 grams. The most important woody food plants were dwarf and staghorn sumacs. In times of deep snow rabbits subsisted upon the bark of woody plants. When herbaceous foods were available very little bark was eaten. Upland and lowland brush containing ground holes was the most effective natural winter cover. Stands of conifers less than ten years old which had been artificially planted formed apparently ideal cover without ground holes. Among rabbits shot during cold weather there was a preponderance of males. This is apparently due to a tendency of the females to hole up more readily during severe weather. In a winter of deep snows and intense cold, rabbits were conspicuously more concentrated in woody coverts than during a mild and open season. A study of the individual ranges of rabbits indicates that most of the animals occupied areas from 5 to 10 acres in extent. The most favorably located rabbits had the smallest known ranges. There was no evidence of "territorial" tendencies in the winter. The most serious winter disease was an infection of the eyes by a pus-forming bacterium, *Staphylococcus albus*. On the area studied, only 7.1 percent of a December population is known to have lived to a second winter. Only 2 individuals of a known population of 228 animals were recorded as having survived to a third winter.

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# COOING ACTIVITY AND CENSUSING OF THE MOURNING DOVE[1]

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While observing mourning doves (*Zenaidura macroura*) in southwestern Iowa, it became apparent to the observer that cooing of the group as a whole was greatly affected by phenological conditions. Observations were begun at Lewis, Iowa, March 26, 1938 and from then until October 15, 1938 the cooing activity for every hour of every day was recorded. A cold snap between September 16 and 20 accompanied by a steady drizzle, wind, and slight frost brought an end to courting. No eggs were laid after September 17, but, of course, eggs were incubated and young that were already in the nests were reared. Cooing practically ceased after September 17, only an occasional bird uttering one or two calls. Between March 26 and September 17, 2,254 observations of cooing activity were made.

A five-minute count at the end of each hour of the day constituted an observation, and during each five-minute period the number of coos heard and the number of birds cooing were counted. Records were kept of the hour of day, temperature, weather, wind speed, and the estimated distance each cooing bird was away from the observer. During these 2,254 observation periods 4,101 birds cooed 45,994 times. This averaged 1.8 birds heard at each count, 11.2 coos to a bird, and 20.4 coos to an observation.

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The work on this project was done under the supervision of Dr. Geo. O. Hendrickson, Assistant Professor in Wildlife Management, Iowa State College, and T. G. Scott, U. S. Biological Survey.

## Cooing

Both the male and female coo, but the note of the female is weak and not melodious. The calling as heard at a distance is that of the male. Each call is made up of five to seven notes; one note, then a higher one, and finally three to five lower notes held at greater length. Cooing is done both on the nest and away from it. When a male is courting a female or is singing to one on a nest he perches on the highest dead branch of the tallest tree in the neighborhood. If courting, he coos several times in succession, leaps from his perch, flies in a steep, whistling climb for 50 to 100 yards, often attaining heights of 150 feet or more, then banks to the right or left, and with wings rigid and tail spread, sails in a great arc back to the same perch, or to the female. When feeling especially ardent he emits coos three to five times a minute. If just cooing to his mate on the nest, he may give only one call a minute, and it may not be loud. Whereas it takes several seconds to complete a coo, when the dove population is high, it is difficult to distinguish many more than one hundred complete calls in five minutes.

In giving the call the male arches his neck, puffs out the throat, stiffens the

body, and bobs the tail at each note. Since the call has ventriloquial qualities, this tail bobbing is a distinct help in detecting the singing bird. The observer may locate five or six birds in the range of his vision and hear one or two birds cooing. The sound seems to come from all directions at once and estimating the distance away that the bird might be is not easy, hence watching for these tail movements is important. The tendency at first is to overestimate the distance. I recall making estimates of "bird 500 yards away" only to find that it was in a tree not fifty yards away, and on one occasion I recorded "bird probably 100 yards away, but can't locate it" and then found that it was sitting on a wire directly above my head. A little practice, however, makes one quite accurate in spotting the cooing birds.

Doves make numerous other sounds and modified coos of which only two will be mentioned here. Occasionally either sex may be heard giving a warning call that is a series of uniform short notes uttered at the rate of 10 or more a minute. The noise made by the dove in flight is a subject of much discussion, some observers claiming it is made by the throat and others by the wings. It is my opinion that the sound is from the throat, for it is made during the down stroke of the wings and seems to be the result of the compression of the lung cavity by the force of the stroke. It is controllable, for I have seen birds fly swiftly by with no sound and we have some birds in captivity that do or do not make the noise seemingly as they please.

## COOING IN RELATION TO TIME OF DAY (Table A)

As the accompanying table indicates, cooing activity was greatest early in the morning and just before sundown. From early morning until early afternoon both the number of coos heard and the number of birds cooing decreased regularly. From early afternoon until just before sundown cooing increased regularly, but the evening activity was never as high as that of the morning.

This may be correlated with the daily program of the birds. They awaken at dawn and in the early morning coo, preen, feed, water, and if nesting, relieve the sitting birds. Most

TABLE A

RELATION OF COOING ACTIVITY TO TIME OF DAY. AVERAGES OF FIVE-MINUTE OBSERVATIONS AT EACH HOUR OF EACH DAY, MARCH 26 TO SEPTEMBER 17, 1938

| *Time* | *Number of coos* | *Number of birds cooing* | *Time* | *Number of coos* | *Number of birds cooing* |
|---|---|---|---|---|---|
| 5:00 A.M. | 67 | 5.0 | 12:00 M. | 12 | 1.2 |
| 5:30 | 63 | 4.3 | 1:00 P.M. | 8 | .9 |
| 6:00 | 59 | 4.5 | 2:00 | 7 | .9 |
| 6:30 | 57 | 4.3 | 3:00 | 7 | .8 |
| 7:00 | 36 | 2.9 | 4:00 | 9 | 1.0 |
| 7:30 | 30 | 2.5 | 5:00 | 16 | 1.5 |
| 8:00 | 24 | 2.3 | 6:00 | 28 | 2.2 |
| 9:00 | 17 | 1.8 | 7:00 | 31 | 2.6 |
| 10:00 | 10 | 1.1 | 8:00 | 26 | 2.2 |
| 11:00 | 10 | 1.0 | | | |

courting and nest building also is done in the morning. As the day warms, doves thoroughly preen their feathers. They may feed again around 10:30 A.M., at noon, and at 3:30 P.M., although these feeding periods may be omitted. Many hours are spent resting, especially during hot weather, when the birds may be seen roosting on telephone or light wires with their wings spread, cooling themselves. As evening approaches they feed, water, make another brooding shift, coo some more, court, and possibly bathe. Bathing varies with the bird and may be done any time of day. Cooing during the heat of the day is erratic and variable. Occasionally some birds will coo during brilliant moonlight nights.

As the season progresses the periods of greater cooing activity follow the sun, becoming earlier in the morning and later in the evening as the days lengthen and vice versa as they shorten.

### COOING IN RELATION TO TEMPERATURE (Table B)

The cooing activity was not greatly affected by temperature, except by extremes. Hence, from 5°C. to 25°C. it was very uniform, there being only a slight peak of activity between 10° and 15°C. The doves did not coo when temperatures went below freezing nor did they coo as much when it went above 25°C.

TABLE B

COOING ACTIVITY IN RELATION TO TEMPERATURE BETWEEN MARCH 26 AND SEPTEMBER 17, 1938. AVERAGES OF FIVE-MINUTE OBSERVATONS

| *Temperatures* | *Number of coos* | *Number of birds cooing* |
|---|---|---|
| 0°C. | 5 | .5 |
| 1°– 5° | 22 | 1.8 |
| 6°–10° | 24 | 2.2 |
| 11°–15° | 30 | 2.1 |
| 16°–20° | 27 | 2.3 |
| 21°–25° | 22 | 2.0 |
| 26°–30° | 15 | 1.6 |
| 31°–40° | 10 | 1.1 |

### COOING IN RELATION TO WEATHER (Table C)

More birds cooed during clear weather than at other times. This does not necessarily mean that doves are only fair-weather creatures, for they coo on cloudy days when the wind is not too strong, and also sing in the rain. If a rain is not heavy, gusty, or cold, a male or two usually can be heard, but on the whole cooing decreases with increasing nebulosity.

TABLE C

COOING ACTIVITY IN RELATION TO WEATHER CONDITIONS BETWEEN MARCH 26 AND SEPTEMBER 17, 1938. AVERAGES OF FIVE-MINUTE OBSERVATIONS

| *Weather* | *Number of coos* | *Number of birds cooing* |
|---|---|---|
| Clear | 24 | 2.1 |
| Partly Cloudy | 19.5 | 1.9 |
| Cloudy | 21 | 1.9 |
| Rain | 15.6 | 1.3 |

### COOING IN RELATION TO WIND (Table D)

Wind had a decided effect upon dove activity. Nests are built on parts of trees away from prevailing strong winds; the birds fly less and court less in the wind, and also coo less. On a clear calm morning cooing seems rampant, especially since audibility is good and the coos can be heard longer distances. Being able to hear many males cooing stimulates others to coo, until,

where large numbers are nesting, bedlam results. Light winds decrease audibility somewhat and also reduce cooing activity. Medium winds lower it still more and strong winds tend to stop it entirely.

TABLE D

RELATION OF COOING ACTIVITY TO WIND, MARCH 26 TO SEPTEMBER 17, 1938. AVERAGE OF FIVE-MINUTE OBSERVATIONS

| *Wind* | *Number of coos* | *Number of birds cooing* |
|---|---|---|
| Calm | 36 | 2.8 |
| Light wind | 24 | 2.2 |
| Medium wind | 17 | 1.6 |
| Strong wind | 9 | 1.2 |

## COOING IN RELATION TO MONTHS

Cooing activity during the breeding season was very constant. It was less in March which was cold, and less in September and October as breeding activities ceased, but from April to August, inclusive, the cooing activity was nearly constant with but a slight rise in May and a slight drop in August. If the months are paired April-May, June-July, and August-September, the June-July groups shows an activity of 6.8 per cent more cooing than the others, but this is hardly significant.

## CENSUSING

Since there is a direct relationship between the number of Mourning Doves present in an area and the number cooing, it is possible to determine populations by counting the cooing birds. At Lewis the population averaged two birds to an acre and at the end of the summer the spring population had increased two and a half times. The following method of censusing doves is based upon the information summarized in the foregoing tables.

*Census Procedure.* The most reliable time of day for censusing doves is from 5:00 A.M. to 9:00 A.M. and from 5:00 P.M. to 8:00 P.M., or from sunup to 9:00 A.M. and from 5:00 P.M. to sundown. During the heat of the day doves coo, but this activity is erratic and not reliable for accurate censusing. Censusing is done in the following steps:

1. Enter the area to be censused, stop, and listen for five minutes.
2. During these five minutes record the number of birds singing within 100 yards in all directions. Or, if no doves are singing within 100 yards of the observer, estimate the distance away of the farthest dove that can be heard. Considering the observer at the center of a circle with the radius of 100 yards, or more, he can then compute the acreage of the area over which he is listening.
3. Record the estimated distance of the farthest birds, if none are singing within 100 yards.
4. Record the time of day to the nearest hour, or half hour in early morning.
5. Record the temperature.
6. Record the weather conditions, as clear, partly cloudy, etc.
7. Record the wind as calm, light, medium, or strong. A light wind is here construed as being but a breeze. A medium wind is strong enough to sway the trees, but not to shake out the eggs or young. A strong wind is one that blows up clouds of dust, is gusty, howls around eaves, and snaps tree tops back and forth enough to roll dove eggs out of the nests. In western Iowa strong winds pre-

vailed during 30 per cent of the daylight hours.

8. When these records are completed, move on through the area to a point so distant that none of the birds recorded can be heard again, and repeat the procedure. Cover the census area so that you have several records from each type of cover, as farmyards, towns, gullies, woods, and others.
9. Since only breeding birds coo and the young do not breed until the year after hatching, a census can be made from April to September. Now with the data on hand, determine the population of adult birds by means of the following tables.

TABLE 1

TIME OF DAY

| *Time* | *Factor* | *Time* | *Factor* |
|---|---|---|---|
| 5:00 A.M. | 2.60 | 11:00 | 12.15[1] |
| 5:30 | 3.02 | 12:00 M. | 10.83[1] |
| 6:00 | 2.88 | 1:00 P.M. | 14.44[1] |
| 6:30 | 3.02 | 2:00 | 14.44[1] |
| 7:00 | 4.48 | 3:00 | 16.25[1] |
| 7:30 | 5.20 | 4:00 | 13.00[1] |
| 8:00 | 5.65 | 5:00 | 8.66 |
| 9:00 | 7.22 | 6:00 | 5.91 |
| 10:00 | 11.81[1] | 7:00 | 5.00 |
| | | 8:00 | 5.91 |

[1] Less reliable.

TABLE 2

TEMPERATURE

| *F.* | *C.* | *Factor* |
|---|---|---|
| Up to 32° | 0° | 26.00[1] |
| 33° to 41° | 1° to 5° | 7.22 |
| 42° to 50° | 6° to 10° | 5.91 |
| 51° to 59° | 11° to 15° | 6.19 |
| 60° to 68° | 16° to 20° | 5.65 |
| 69° to 77° | 21° to 25° | 6.50 |
| 78° to 86° | 26° to 30° | 8.12 |
| 87° to 104° | 31° to 40° | 11.81 |

[1] Less reliable.

TABLE 3

WEATHER

| *Weather* | *Factor* |
|---|---|
| Clear | 6.19 |
| Partly Cloudy | 6.84 |
| Cloudy | 6.84 |
| Rain | 10.00 |

TABLE 4

WIND SPEED

| *Wind* | *Factor* |
|---|---|
| Calm | 4.64 |
| Light | 5.91 |
| Medium | 8.12 |
| Strong | 10.83 |

TABLE 5

AREA REPRESENTED BY BIRDS COOING

| | |
|---|---|
| 50 yards | 1.7 acres |
| 100 " | 6.5 " |
| 150 " | 14.6 " |
| 200 " | 26.0 " |

*Example of determining a population:*

1. Observer's record: Time, 6:00 A.M.; 3 birds cooing within 100 yards; temp., 18°C.; weather clear; wind, calm.
2. Add the factors for time, temperature, weather, and wind as given in tables 1, 2, 3 and 4; i.e., $2.88 + 5.65 + 6.19 + 4.64 = 19.36 \div 4 = 4.84$.
3. Multiply the number of birds cooing by this result; i.e., $3 \times 4.84 = 14.52$ birds.
4. Since these birds were cooing within 100 yards of the observer, determine the number to an acre from table 5; i.e., 14.52 birds $\div 6.5$ acres $= 2.25$ birds per acre.
5. When all observations have been computed, find the average number of birds per acre and multiply by the acres in the census area.
6. To determine the possible fall population, multiply the adult population just determined by two and one-half. (This factor may vary according to the year and locality.)
7. If the census is made during June and July, the birds at that time are 6.8 per cent more actively cooing than in April to May or

August to September, so it is necessary to reduce the total by that proportion which may be done by multiplying it by 93.2 per cent.

Open seasons on morning doves are allowed in 28 states. It is imperative therefore that a quick, accurate, and practicable method of censusing be developed. Since the method here described is based wholly on observations and numbers of doves in Iowa, it should be critically tested in other States. The writer hopes that workers elsewhere will try this census method in comparison with others and inform him or publish the results.

## SUMMARY

Cooing activity of mourning doves at Lewis, Iowa, from March 26 to September 17, 1938, was recorded in 2,254 observations. Each observation was made for five minutes at the end of each hour of the day.

During this time the doves cooed an average of 20.4 times in each five minutes, 1.8 birds cooed, and there were 11.2 coos to a bird.

Cooing was greatest in the early morning, least at mid-day, and increased again in the evening before sundown.

Temperatures except below freezing and above 25°C. had little effect on the cooing activity, but it decreased with increased nebulosity, and wind speed.

Cooing activity was nearly uniform from April through August.

From this information a method of censusing the birds is described and census tables are given.

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# A METHOD OF TREE CLIMBING[1]

*H. Elliott McClure*

During spring, summer, and fall of 1938 the nesting habits of the mourning dove (*Zenaidura macroura*) were observed in the region of Lewis, Iowa. Since doves nest at an average height of 14 feet in the country and 22 feet in town, it was necessary to do much climbing.

When trees are easily climbed by shinning or, as with conifers the limbs are low, the problem of reaching a nest is simple. If a tree is too large to shin up, the limbs are high, or the nest is in a dangerous position, however, a rope should be employed.

The research was under the direction of Dr. George O. Hendrickson, Assistant Professor, Wildlife Management, and Thomas G. Scott, United States Bureau of Biological Survey.

I used the standard methods of climbing that tree experts or linemen practice. Since all trees climbed were shade or fruit trees, climbing irons could not be used. Because many nests are 40–50 feet high, at least 100 feet of $\frac{5}{8}''$ rope is needed. Half inch rope is more flexible but $\frac{5}{8}''$ rope handles well after it has been used a while.

The ends of the rope should be wrapped with fine wire or strong cord to prevent unraveling.

The three essential knots are shown in the accompanying illustration (Fig. 1) and even these need not always be used.

[1] Journal Paper No. 631 of the Iowa Agricultural Experiment Station. Project No. 565. In cooperation with the U. S. Biological Survey, the American Wildlife Institute, and the Iowa State Conservation Commission.

If a nest can be reached without much danger, then the seat made of a double bowline is not necessary. Throwing the rope over the highest limb that can be reached without permitting intervening limbs to stop it takes considerable practice. The knot used as a weight in this operation is shown in Figure 1 A. Take three or four bights (loops) about 18 inches in diameter near the end of the rope. Then grasping these in one hand, wrap the rope around them from the hand out. When most of the length of the loops has been wrapped, pull a loop of the long rope through the bights and hold the knot as shown in Figure 1 A. Take several large coils of the rope and grasp them with the hand holding the weight knot and toss it over the highest available limb. As the knot comes down on the opposite side it unties itself. If it does not readily do so, snapping the rope loosens it and it will unravel. Now you can climb up the trunk using the rope as a support.

Because word description of knots is difficult, have a lineman or scoutmaster show their formation. If a nest is high in a tree or in a dangerous position, a seat should be made and the climber should at all times have the rope as a support. Two knots are necessary, the double bowline shown at the top of the illustration (Fig. 1 B, C, D) and the rolling hitch shown at the right (Fig. 1 E). It is simplest to tie the double bowline in one end of the rope while on the ground. Be sure to leave several feet of rope as a loose end beyond the knot. When the double bowline (Fig.

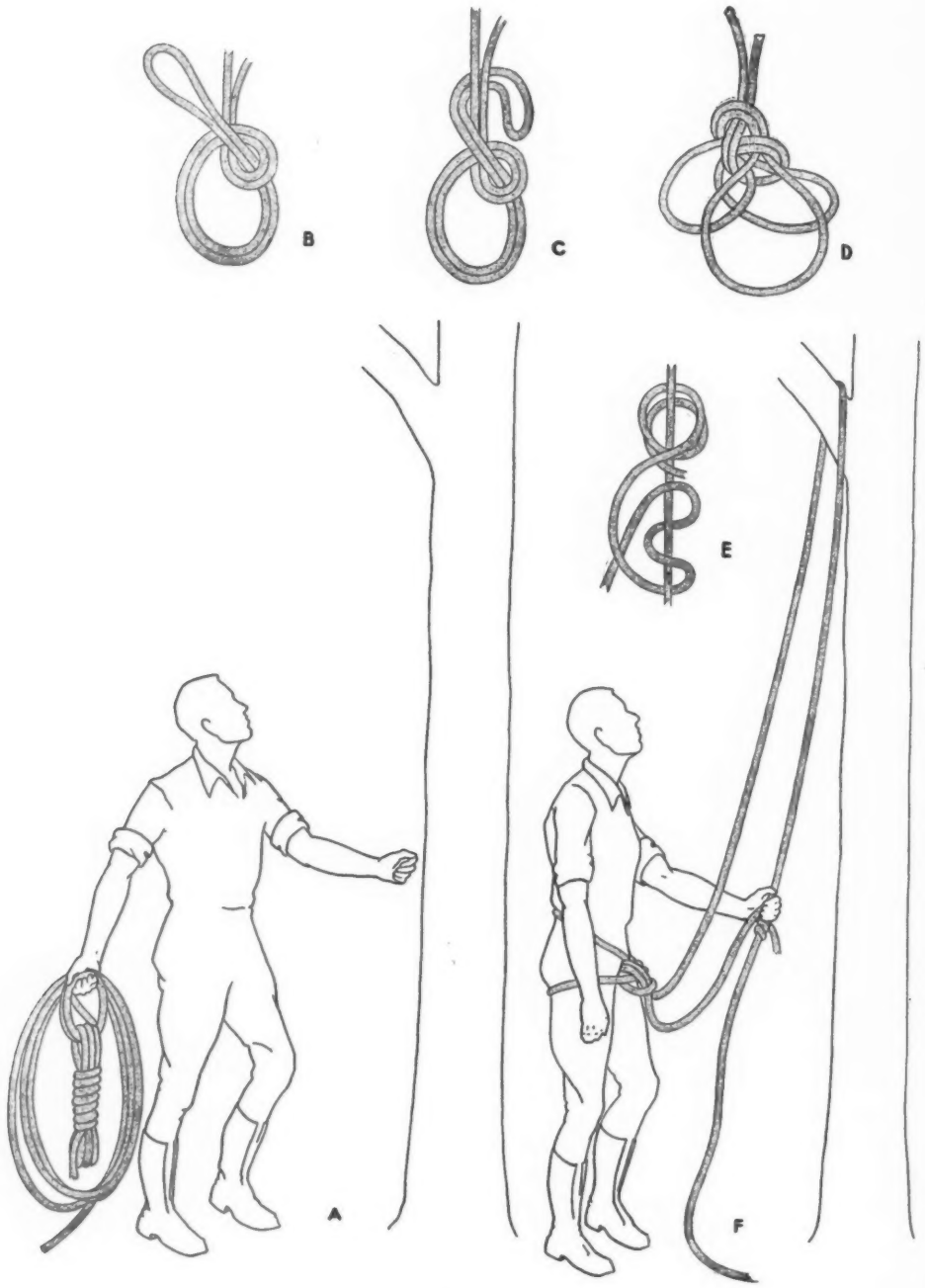


Figure 1

1 D) is tied the large loop can be made to fit the body and the small loops the legs by adjusting the knot. Now make the weight knot on the opposite end of the rope, throw it over a limb and begin climbing. Continue to climb, throwing the rope on above you when necessary, until you have reached the highest crotch that you believe will support you. This is the only dangerous part of the climb. Pull up the end of the rope with the double bowline in it and put your legs and body through the loops. Tighten the loops and knot until they fit snugly (Fig. 1 F). This knot will not slip and bind you. With the short end of rope which extends beyond the double bowline tie a rolling hitch around the long rope that hangs down from the opposite side of the crotch, as shown in the illustration (Fig. 1 F). This rolling hitch is very simple and consists of two overhand and two underhand loops about the long rope (Fig. 1 E). Now you can let go of the tree, and the rope will support you. To go down, take hold of the rolling hitch and pull. It slacks and you descend, but when you let go of the knot it tightens and your descent is stopped. With this support you can climb all over the tree, being careful not to foul your lines, and be in no danger of falling. Forcing your weight against the rope you can walk out limbs with your hands free. Learn the use of the rolling hitch thoroughly, for it is your life guard.

When the rope is not in use it can be coiled and carried easily. If you wish to slide down the rope from a horizontal limb, loop it over the limb so both ends touch the ground. Then wind the rope around one leg once and with the other foot catch the rope between the feet. In this position the rope slides around the right leg and down across the inside of the foot. The legs are crossed and the left foot catches the rope so that it extends under the arch of the right foot and over the top of the left foot. This way you can brake on the rope so as to slow your descent. By the same means the rope may be climbed, like a toy monkey up a string, with the feet and legs doing the work instead of the arms and shoulders. This is much less tiring than climbing hand over hand.

Simple as this method of climbing is, it safeguards the observer and leaves his hands free for measuring eggs, banding birds, or photographing. I climbed over 700 trees an average of five times each during the season and took only one fall. This occurred when a limb gave way and I was not in the rope. As I was up only 15 feet no damage was done, except to the tree and birds.

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# ON THE NATURE OF COVER

*Charles Elton*

Cover is a magic word in wildlife management. It is, indeed, often a magic wand with which wild animals and birds are made to populate places formerly uninhabitable, or unfavorable for increase. Nevertheless, we know very little about the nature of cover and the part that it plays in the protective system of the prey. Since wildlife management seeks to develop its practice on a basis of scientific principles, rather than upon the blind practical tests which have obscured other fields of applied ecology when policy has outstripped science (e.g. in many phases of pest control), it seems desirable that we should seek to analyze the complex nature of cover more carefully than has hitherto been done. The enormous scale upon which cover is being encouraged in connection with schemes of wild life preservation and restoration, and of soil erosion control, makes this need really urgent. Although the problem is very complex and subtle, and is unlikely to yield its secrets any more easily than other branches of wildlife ecology in which the hope of quick solutions has given way to patient research, yet certain principles can be suggested that may aid in planning research on cover. No doubt it will be found that the ideas put forward in this essay are oversimplified. It is not even likely that they are entirely new. At any rate they were a new line of thought to me, one that emerged during the casual observation, during a holiday, of two young cats practising, in a room full of old furniture, the game of predator and prey. Each in turn would stalk the other, and one could observe, in this transparent diagrammatic play, the various phases of search, pursuit, escape, and refuge, and the influence of cover on them. Afterwards an attempt was made to extend these lines of thought to predator-prey relations of all kinds, with the following results.

It is necessary to explain first of all that I shall use the idea of cover in a much wider sense than is understood in the relatively limited field of game management, while at the same time illustrating the points so far as possible by means of examples from mammals and birds. Leopold, in his excellent introduction to the subject in his *Game Management* (1933), uses "cover" in the sense of "covert" i.e. vegetation or other shelter for game, his main thought being of game-birds and then of mammals (game or otherwise). There are certain advantages in studying the subject also from a wider angle. I would like to acknowledge here the great stimulus which American investigators such as Leopold, Stoddard, and Errington, have given me, both personally and from their writings on this subject. The following quotation from an essay published in 1938 expresses the point from which one may start thinking of the problem.

"The structure of the earth's surface provides many forms of natural, geological cover, but usually we find this intermixed with organic material also, mostly from vegetation. Examples are the soil and partly organic silt. The

vegetation itself affords an enormously vital type of protective cover. The existence of so much cover greatly increases the chances of a species escaping from its enemies, and makes a form of natural sanctuary, and increases the scarcity of *available* preys for predators (or for parasites searching to lay their eggs in insects, or for organisms of disease). The various strange devices that animals have evolved for escaping detection, by special resemblances to their environment, and the opposite type of device that warns the enemy that he is approaching some food he will not like, and the various forms of bluff that have grown from these devices, are all part of a more general problem of cover."[1] Here the predator-prey relationship is stressed. Before beginning the analysis of its relation to cover, some other aspects must be considered.

As Leopold and others have already pointed out, protection of the prey from predators is only one, though a very vital one, of the effects that cover has. It may provide protection from the physical effects of weather, either at dangerous extremes, or in pleasant optima (Leopold's "loafing cover"): the shade of trees or rocks sheltering deer or cattle or quail from the sun; snow or earth or rocks or holes in trees or nests insulating small rodents and other small mammals, and birds, from winter cold, or the eggs or young from spring and summer cooling; thick scrub acting as a wind-break in which game birds or rabbits can avoid exposure; the hairy coat of the mammal keeping warm its parasites (and itself); the clothes and houses and automobiles of man. Thoreau remarks, in *Walden:* "what pains we accordingly take, not only with our Food, and Clothing, and Shelter, but with our beds, which are our nightclothes, robbing the nests and breasts of birds to prepare this shelter within a shelter, as the mole has its bed of grass and leaves at the end of its burrow!"

In this use, cover is of paramount importance to warm-blooded forms, although it is only one part of what we may call the "physiological protective system" of the species, which includes many other elements, such as food, water, internal physiological organization, structure, and habits. And this system is required by predator and prey alike. It is not always easily separable from the other aspect of cover in the protective system of the prey. For it is now well established that many birds and animals, even very small ones, can survive astonishing extremes of exposure provided that they are able to find sufficient food.

Cover may also provide food. For many herbivorous mammals and birds, as for Hansel and Gretel, their house is edible. Sometimes a species may eat so much of its cover that the value of the latter from other points of view is greatly diminished. This happens directly (and fairly commonly) when voles multiply and erode the grass cover which hides them from predators and from exposure to weather (a fact which has given rise to a whole theory of vole fluctuations, put forward in recent years by Soviet ecologists studying vole outbreaks on the Russian steppes). It also happens indirectly,

[1] Elton, C. "Animal numbers and adaptation." In "Evolution: essays on aspects of evolutionary biology, presented to Professor E. S. Goodrich . . . " Oxford, 1938, p. 133–4.

and over longer periods of time, when deer overgraze their forests and prevent regeneration. It may be found that game birds sometimes contribute, by bud- or seed-eating, to the depreciation of the cover that maintains them. On the other hand, some species, such as the rabbit in England, arrest plant succession and maintain an equilibrium favorable to themselves.

Cover may also give seclusion, or an environment that is psychologically satisfactory in other ways, for the undisturbed prosecution of mating activities, for rest and sleep ("roosting cover"), or for social life and play. Seclusion is not necessarily a question only of immunity from enemies, but also from members of the same species. Several recent experiments on insect populations (*Drosophila*, *Calandra*, etc.) in the laboratory have suggested that the slowing down of reproductive rates at high densities is caused by interruption of the chain of mating behavior through disturbance. How important cover is in this respect among birds and mammals is a matter for more investigation; but it is at any rate a strong psychological need for the mating activities of the human race. And I shall suggest, at the end of this paper, that most of the effects of cover play a big part in human, as well as in animal ecology.

Nesting cover and cover for travel lanes fall chiefly under the general heading of protection from enemies, which has now to be considered. We have seen that this protection is only one of the effects that cover may have on a species. Reflection will show that cover is only one of the components of a wider system which I propose to call "the protective system of the prey"—protection here being primarily from predatory enemies, although the concept can be extended to include certain aspects of competition between members of the same species. Suppose we analyze the phases which may occur in the searching of a predator for its prey. The problem of predator-prey relations has already been the subject of immense abstract researches by mathematicians and ecologists, whose formulas are of considerable importance. However, I wish to approach the matter from a rather different angle, dealing with processes that can be actually observed in the course of ordinary field experience with birds and mammals. We can suppose that a fox is searching for partridges, a weasel for mice, a hawk for quail. The exact combination of predator and prey is not so important, but it must be one kind of predator searching for one kind of prey. The complexity of other species can be added afterwards.

There are three phases in this searching process: (1) *Random searching*, (2) *Pursuit*, and (3) *Refuge*.

(1) *Random searching*. During this phase the predator is out hunting, on the look-out for a particular kind of prey. It may have experience or an instinctive impulse which leads it to search a particular area in a skillful and purposive way; but it is not in contact with the prey through any of its senses. The prey is not heard or seen or smelt. In this phase we also assume that the preys are moving about their normal business of life, without knowledge of the whereabouts of the enemy, though they likewise may frequent certain parts of the area, may conceal

their movements in a skillful way, and may even be acting on experience of the previous movements of the enemy. The phrase "random searching" therefore does not mean that the movements of the two forms are made in an entirely pointless manner. They are not even necessarily made without reference to previous experience of predation. But the movements are here understood to be random in the sense that each form is ignorant of the exact whereabouts of the other at a given moment. The distinction is essential for an appreciation of the problem.

In this process of random searching both species may be moving about. There are certain conditions of density and characteristics of the two species under which they would never meet. In these conditions the predator would have to find an alternative food supply or starve. But we are here studying an instance in which the predator is alive and flourishing and is going to have a good chance of eating before it is faced with this problem. It is, however, not necessary that active "searching," in this sense, should occur in both species. The predator may be stationary (a leopard on a tree waiting for a passing animal or man; or a web spider catching insects; or a marine coral colony catching plankton forms).

Now, it is also not necessary that cover should exist at all in order that this situation may occur. Many marine animals (such as whales and fish) maintain themselves on plankton organisms without entirely depleting them. The flight of bats and moths at night, or of swallows and day-flying insects, are two other examples. But in most communities cover has an immense effect on random searching for prey. The chief thing is that it places barriers between the senses of the predator and the prey. If the moving prey perceives its enemy without itself being perceived, and hides, the process of random searching still goes on, but to the disadvantage of the prey, whose normal activities are being curtailed. The prey may take safe refuge without being noticed at all, which, though disadvantageous, is better than death. Here the second phase is cut out. But usually, sooner or later, a contact is made between the predator and the prey and there follows the second phase—pursuit.

(2) *Pursuit.* With this phase there is an abrupt change of tempo in the movements. Sometimes the predator may detect its prey before being noticed itself. Usually, with terrestrial hunting animals, this means the beginning of a stalk, so that the enemy continues undetected during pursuit. Even without a stalk, there is an initial advantage to the predator in its rush or pounce or dive. But there is often a sudden change in the behavior of the prey as well, while it takes to flight. The influence of cover on pursuit is extremely important, and often of a different kind from its influence on random searching. It may make the predator lose track of the prey, through its complexity of structure and the multiplicity of possible paths. This brings the situation more or less back to random searching again. A multiplicity of trails of scent left by different individuals may also have the same effect. Or cover may, by its shape and texture, delay the enemy or confuse its senses. The prey being usually smaller than

its enemy, can fly or run where the predator cannot. Finally the prey may reach a part of the cover into which the predator cannot penetrate at all. This is the third phase—refuge. The prey may, however, elude its pursuer before reaching a refuge, which takes the situation back again to phase (1).

(3) *Refuge.* This may be formed in many ways, depending on the size and other qualities of the animal—and of its enemy: holes in ground or rocks or trees; up trees; vegetation of dense texture or unpleasant quality; water; the air. For immediate protection a refuge may be efficient, but an animal has to come out eventually in order to live. Here there will be a balance between the need of the predator to get food within a certain time (which usually leads it to search elsewhere instead of waiting outside a refuge), and similar need of the prey. There is a clear distinction to be made between refuges from pursuit (which are not permanent habitats) and habitats that may confer permanent immunity from certain classes of enemy (as with endoparasites of animals, or insects living inside plants, or aquatic versus terrestrial forms). But hibernating and aestivating animals are a special class that periodically spends a long time in the refuge; while many species use their pursuit-refuge for sleep by day or night.

Cover, though very important in refuges, is not always necessary. For a prey may reach sanctuary and yet remain in full sight of the enemy, as when a dog trees a squirrel and yet cannot reach it.

It will be obvious that this cycle of random searching, pursuit, and refuge involves a great many factors besides cover. From the point of view of the prey, cover is only one of the conditions which may enable it to elude detection, defeat pursuit, and reach a refuge. The following things seem to be combined in the whole protective system of the prey: (1) The physical qualities and behavior of the prey; (2) the physical qualities and behavior of the predator; and (3) the qualities of the environment as: (a) physical nature of topography, soil and vegetation, acting as cover, barriers, and background; (b) the surface conditions of the ground; (c) conditions of the atmosphere; and (d) associated animals.

The influence of the physical qualities and behavior of the prey, such as size, speed, color, and quickness of sense, needs no stressing, and is much too large a field for thorough discussion here. But each predator-prey relation will interact differently with the environment, according to the nature of these qualities and behavior. And cover will vary in significance, with the rest of the environment. Nocturnal habits are a means of obtaining an almost perfect cover from many predators, and profoundly affect the kind of predator-prey relations that occur. Phrases like "the cover of night" or "the cloak of darkness" show how we are impressed with this circumstance. The size of animals in relation to the texture of cover, the use of protective colors and camouflage, the relation of quickness of sense to that handicap start which may decide the death or escape of a prey, are other examples of the need for studying cover in relation to the qualities of the animals concerned.

The physical conditions of the environment comprise a great many things besides vegetation cover, though the latter receives most attention in practice because it is the one that can be most controlled and molded. But the shape of the ground (giving good visibility, or dead ground), the texture of the rocks and soil, and proximity to water, are vital for many species. The surface conditions (mud, snow, rocks, steepness) all affect speed and tracks, and some (as snow) vary to an important extent. The state of the atmosphere affects surface conditions, and also visibility and scent. The alternation of night and day is a most important condition, because few species are active at both periods, and therefore have to have refuges or other means of protection during their period of rest. Associated animals not infrequently give the alarm; while they may also provide buffer species that deflect the enemy, as Leopold has pointed out.

Enough has been given to show that cover has several effects, of which protection from enemies is probably the most important. But it is only one of a complex of conditions which affects the escape of a prey. This complex itself acts differently in the three phases of random search, pursuit, and refuge, which operate in the protective system of the prey. Cover plays a large part in all three of them. The operation of all these processes is different for each predator-prey species interaction. The application of the idea of cover chiefly to vegetation cover in game management is only a convenient practical convention, based on the possibilities of human control, rather than on ecological reality. If a mammal or game-bird had a point of view, it would be: "How can I *escape detection*, or *escape pursuit*, and *hide*. I will exploit any means to this end." That is why it is going to be more profitable for research to study the *protective system of the prey* as a whole, including, of course, cover as one of the vitally valuable elements. By this means we may bring into one scientific body of knowledge the quail squatting in its scrub, the red deer invisible against its background of hill moor, the sloth with its green alga-covered fur, the swaggering skunk, and the ostrich running over a coverless desert. For what is the sloth but a walking biotic community (there is a moth that eats the alga); or the porcupine but a walking refuge?

These general ideas suggest that the present methods of measuring the efficacy of cover could be extended to allow of a finer analysis of the components. We now take the density reached or maintained by game-birds as a measure of their cover efficiency. We require, for knowledge of its efficiency in protection from enemies, to count the number of random contacts between predator and prey made in a given time, and the percentage of these in which pursuit is effective. The inverse of the second figure would measure the effectiveness of escape and refuge. For we lack at present a method of discriminating between the different effects of cover on a species. Cover can be described, in the sense that we can give a statement of its vegetation composition, height, area, nature of soil and so on. But we require also to be able to describe the way in which it influences population density,

and for this purpose it is best to use population behavior and dynamic changes as a measure. The quantitative relations between predator density and the nesting losses of game-birds offer an obvious field. Here, incidentally, we may see the significance of desertion, as being the reaction to a change from the situation of random searching by enemies to one of stalking or non-random searching.

It would be fascinating to follow these ideas further, into human ecology, some phases of which, especially at the present time, might legitimately come under the heading of wildlife management. And this suggestion is made seriously, because the predator-prey relationship between man and game-birds and animals, involving the whole behavior-pattern of food-getting and "blood sport," provides a great part of the driving force behind wildlife management. In such a sport as fox hunting in England, we can see clearly shown every phase of the principles set out in this essay: random searching, the pursuit (often with escape), the refuge (often effective), the importance of cover, of the qualities of the hunter and the prey and of the ground and the weather. The universal criterion of good sport, namely, that the prey has a chance of escape, ministers to man's primitive behavior-pattern in the chase. We may perhaps see these feelings translated, though in a more obscure form, into the innumerable games in which a ball is chased and seeks sanctuary in a hole, a net, a goal or a boundary, or in which (as in baseball) the man himself is the hunted prey running swiftly to refuge. In these ball games we may experience or share vicariously the delicious double sensation of being the prey and the predator alternately. For we must remember that primitive man held a middle position in his food chain, at one time being stalked by predators, at another hunting game himself. He had, ecologically, something of the same position as a mole or an insectivorous bird or a young perch.

There may, therefore, be a fundamental resemblance between the chase (also fishing and other field sports) and games of ball, and this may prove of considerable significance in the ultimate preservation of wildlife, since the latter depends so much on the whims and pleasures of the human population of the world. Here is a situation susceptible to investigation and possibly the control of equilibrium between different forms of predation in sport.

Finally, there is another aspect of human life in which cover has a paramount significance—War. Again one can perceive the sequence of phases, and how the relative importance of random searching and pursuit has waned, to give place to the dominant consideration of cover. At the present time we are going through a period in which there is some doubt whether even the enormous power resources at our disposal can produce enough cover to shelter the human race from itself.

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# THE RELATION OF LOONS, HOLBOELL'S GREBES, AND COOTS TO DUCK POPULATIONS

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As part of a study of waterfowl populations in the Cariboo region of British Columbia during the summers of 1936–38, inclusive, an inquiry was made into a possible correlation between the presence of the lesser loon (*Gavia immer elasson*), Holboell's grebe (*Colymbus grisegena holboelli*), American coot (*Fulica a. americana*), and mortality in duck broods. The results obtained in the year 1936 have been recorded (Munro, J. A., The Condor, Vol. 38, 1937, pp. 163–173). Additional data obtained in the two years following, together with the quantitative data previously used, are assembled in the present paper.

The methods of study were: (1) Quantitative treatment of waterfowl enumerations; (2) observation of mixed waterfowl populations; and (3) a systematic search for dead young on duck nesting or feeding areas at different times during three successive summers. Inspections were made by canoe on open water or navigable marshes and on foot elsewhere. These methods are discussed in the order named.

## Quantitative Treatment of Waterfowl Populations

Table 1 records the number of duck broods, the average number in a brood and the presence or absence of loons, Holboell's Grebes, and coots.

Table 2 presents the number of inspections (which include, in some cases, two counts on the same lake when these were taken in different years), the total number of duck broods, and the average number in the broods.

The tabulated data are of limited value by reason of such variable factors as: The size and productivity of the areas considered; the different dates of inspection; the variation in normal size of broods in different species (pintail 6–8, lesser scaup 8–15); and the impossibility of isolating and assessing the effect of any one of the supposed predators when one or both of the other two species are present. Nevertheless it seems reasonable to suppose that any large scale reduction of duck broods would be apparent in these series of absolute figures. But no such thing is apparent; the figures in Table 2 indicate that the average size of duck broods is much the same whether one or another of the three species, or any combination of them are present or all are absent.

## Observation of Waterfowl Populations

Opportunities to watch the actions of loons when in the vicinity of duck broods were sought but the following is the only instance observed. At Exeter lake on July 7, 1938, a single loon swam close to a female mallard surrounded by her brood of nine young about one-third grown, this being on the open lake about one hundred yards from the shore. When the loon was about forty feet from the brood it dived and came up at a distance greater by about one hundred feet or so; it then turned and

TABLE 1

DUCK BROODS AND ADULT LOONS, HOLBOELL'S GREBES, AND COOTS OBSERVED IN BRITISH COLUMBIA

| *Locality* | *Date visited* | *Duck broods* | *Average number* | *Loon* | *Holboell's grebe* | *Coot* |
|---|---|---|---|---|---|---|
| Lake 3 Clinton 5 acres | June 30, 1938 | 1 | 5 | 0 | 0 | 0 |
| Lake 6 Clinton 50 acres | 30 | 3 | 9 | 0 | 0 | 0 |
| Lake 7 Clinton 1 acre | 30 | 1 | 1 | 0 | 0 | 0 |
| Lake 9 Clinton 50 acres | 30 | 10 | 6.4 | 0 | 0 | 0 |
| 103-mile Lake 75 acres | July 3, 1938 | 11 | 7 | 0 | 2 | 1 |
| 105-mile Lake 100 acres | 3 | 7 | 7.8 | 1 | 12 | 8 |
| Williams Lake East End 1 M. | 4 | 5 | 4.4 | 3 | 5 | 24 |
| Talton Lake 1¼×¼ M. | 5 | 12 | 7.2 | 2 | 2 | 12 |
| Lily Pad Lake 1½×⅛ M. | 6 | 14 | 7 | 2 | 2 | 15 |
| 101-mile Lake 6 acres | 7 | 3 | 6.3 | 0 | 2 | 6 |
| Exeter Lake 1×¾ M. | 7 | 12 | 7.4 | 1 | 0 | 0 |
| Westwick Lake 1¼×¼ M. | 9 | 6 | 7.6 | 0 | 0 | 20 |
| Sorenson Lake ½×⅛ M. | 9 | 16 | 7.3 | 0 | 0 | 18 |
| 121-mile Lake 100 acres | 11 | 3 | 6 | 0 | 0 | 6 |
| 149-mile Lake ½×⅛ M. | 12 | 16 | 8.5 | 0 | 0 | 30 |
| Slough 108 M. Ranch 10 acres | 13 | 5 | 7 | 0 | 0 | 7 |
| Soda Lake 1×⅝ M. | 13 | 3 | 6.6 | 0 | 0 | 0 |
| Lake of the Woods 10 acres | 13 | 6 | 6.3 | 0 | 0 | 2 |
| Lake 6 Clinton | July 13, 1937 | 1 | 6 | 0 | 0 | 0 |
| Lake 7 Clinton | 13 | 1 | 7 | 0 | 0 | 0 |
| Lake 9 Clinton | 13 | 6 | 3.8 | 0 | 0 | 0 |
| Straight Lake 2×⅛ M. | July 15, 1938 | 13 | 9.2 | 2 | 2 | 2 |
| Simon Lake 1¾×½ M. | 15 | 7 | 8 | 4 | 3 | 8 |
| Disaster Lake 50 acres | 18 | 6 | 4.9 | 0 | 2 | 7 |
| Pete Kitchen Lake 80 acres | 18 | 19 | 6.5 | 1 | 0 | 6 |
| Grus Lake ½×⅛ M. | 18 | 1 | 10 | 1 | 2 | 2 |
| Willow slough 2 acres | 18 | 9 | 5.8 | 0 | 0 | 4 |
| Slough 3 acres | 18 | 6 | 5.7 | 0 | 0 | 4 |
| Pond 1 acre | 19 | 1 | 2 | 0 | 0 | 0 |
| Elliott Lake 25 acres | 19 | 9 | 5.8 | 1 | 2 | 2 |
| Slough 5 acres | 20 | 7 | 8.2 | 0 | 2 | 0 |
| Slough 5 acres | 20 | 1 | 3 | 0 | 0 | 0 |
| Slough 4 acres | 20 | 9 | 6.8 | 1 | 0 | 0 |
| Sepa Lake | 21 | 2 | 7.5 | 0 | 2 | 0 |
| Lake 1 Clinton 5 acres | July 22, 1936 | 2 | 4.5 | 0 | 0 | 0 |
| Lake 3 Clinton | 22 | 1 | 6 | 0 | 0 | 0 |
| Lake 5 Clinton 3 acres | 22 | 1 | 6 | 0 | 0 | 0 |
| Lake 6 Clinton | 22 | 5 | 4.6 | 0 | 0 | 0 |
| Lake 7 Clinton | 22 | 1 | 3 | 0 | 0 | 1 |
| Lake 9 Clinton | 22 | 11 | 4.2 | 0 | 0 | 0 |
| Slough 2 acres | July 22, 1938 | 3 | 5.6 | 0 | 0 | 2 |
| Slough 2 acres | 22 | 1 | 6 | 0 | 0 | 0 |
| Slough 2 acres | 22 | 1 | 6 | 0 | 0 | 6 |
| Slough ¼ acre | 22 | 3 | 6.6 | 0 | 0 | 1 |
| Pond 1 acre | 22 | 1 | 8 | 0 | 0 | 3 |
| Pond ¼ acre | 22 | 2 | 6.5 | 0 | 0 | 1 |
| 150-mile Lake 25 acres | 22 | 15 | 8 | 0 | 2 | 24 |
| 143-mile Pond 1 acre | 22 | 3 | 5.6 | 0 | 0 | 2 |
| Horse Lake 7×¼ M. | July 22–28, 1936 | 11 | 6.1 | 11 | 10 | 2 |
| Horse Lake | July 22, 1937 | 18 | 8 | 17 | 6 | 2 |
| Fawn Lake 1¼×¼ M. | 23 | 5 | 4.6 | 3 | 0 | 0 |
| Sheridan Lake (arm) 1 M. | 23 | 3 | 11.3 | 2 | 0 | 0 |
| Sheridan Slough 5 acres | July 23, 1938 | 2 | 10.5 | 0 | 0 | 6 |
| 102-mile Slough 2 acres | 23 | 3 | 5.3 | 0 | 0 | 1 |
| Abel Lake 120 acres | 23 | 4 | 7 | 2 | 2 | 0 |
| Abel Pond ¼ acre | 24 | 1 | 5 | 0 | 0 | 0 |
| 93-mile Lake 25 acres | 24 | 1 | 6 | 0 | 0 | 0 |
| 93-mile Lake | July 25, 1937 | 3 | 5.3 | 0 | 0 | 0 |
| Disputed Lake 50 acres | 25 | 11 | 8.4 | 1 | 0 | 0 |
| Longbow Lake 1¼×¼ M. | 25 | 16 | 6.4 | 6 | 0 | 0 |

TABLE 1—*Continued*

| *Locality* | *Date visited* | *Duck broods* | *Average number* | *Loon* | *Holboell's grebe* | *Coot* |
|---|---|---|---|---|---|---|
| Irish Lake ¾×½ M. | 26 | 7 | 9 | 0 | 2 | 0 |
| Slough 2 acres | 27 | 3 | 8.3 | 0 | 0 | 0 |
| Slough 4 acres | 27 | 3 | 5.3 | 0 | 0 | 0 |
| Slough 6 acres | 27 | 7 | 5.8 | 0 | 0 | 6 |
| Sherman Lake 10 acres | July 27, 1938 | 1 | 6 | 2 | 0 | 0 |
| Slough 1 acre | 27 | 7 | 7.7 | 0 | 0 | 0 |
| White Horse Lake | 27 | 6 | 7.3 | 4 | 2 | 0 |
| Slough 2 acres | 28 | 2 | 6 | 0 | 0 | 1 |
| Disputed Lake | July 29, 1936 | 7 | 7.3 | 4 | 2 | 0 |
| Anthony Lake 30 acres | July 30, 1938 | 7 | 7 | 1 | 0 | 0 |
| San Jose River (¾ M.) | 31 | 4 | 6 | 0 | 0 | 5 |
| 149-mile Lake | 31 | 22 | 7.1 | 0 | 0 | 20 |
| 150-mile Lake | 31 | 10 | 6.1 | 0 | 1 | 4 |
| 146-mile Pond ½ acre | 31 | 2 | 6 | 0 | 0 | 0 |
| 146-mile Pond ½ acre | July 31, 1937 | 3 | 5 | 0 | 0 | 0 |
| Pond ¼ acre | July 31, 1936 | 2 | 6 | 0 | 0 | 2 |
| Pond 1 acre | 31 | 1 | 7 | 0 | 0 | 4 |
| Pond 1 acre | July 31, 1937 | 3 | 7.6 | 0 | 0 | 4 |
| Pond 1 acre | 31 | 5 | 7.1 | 0 | 0 | 6 |
| Tad Lake ¾×⅛ M. | August 1, 1938 | 4 | 8 | 2 | 1 | 0 |
| Lake 50 acres | August 2, 1937 | 3 | 5 | 0 | 0 | 0 |
| Pond 8 acres | 2 | 4 | 7 | 0 | 0 | 0 |
| Pond 20 acres | 2 | 6 | 7.1 | 0 | 0 | 0 |
| Pond ¼ acre | 2 | 2 | 6 | 0 | 0 | 1 |
| 149-mile Lake 10 acres | 2 | 14 | 6.4 | 0 | 0 | 46 |
| 150-mile Lake 25 acres | 2 | 13 | 8 | 0 | 6 | 0 |
| William Lake East End 1 M. | 2 | 3 | 6.3 | 3 | 2 | 4 |
| 130-mile Lake 1¼×¼ M. | August 3, 1936 | 8 | 6.6 | 2 | 4 | 7 |
| 105-mile Lake 1¼×½ M. | 4 | 20 | 8.5 | 1 | 14 | 20 |
| 108-mile Lake 1¼×¾ M. | 4 | 1 | 3 | 8 | 4 | 4 |
| 103-mile Lake ¾×¼ M. | August 4, 1937 | 9 | 5.3 | 1 | 2 | 0 |
| Slough 2 acres | August 4, 1938 | 2 | 7 | 0 | 0 | 0 |
| Slough 2 acres | 4 | 2 | 6 | 0 | 0 | 0 |
| Slough 30 acres | 4 | 6 | 6.5 | 1 | 0 | 0 |
| Anthony Lake | August 5, 1937 | 5 | 5 | 1 | 0 | 0 |
| Tad Lake | August 6, 1936 | 3 | 6.3 | 0 | 2 | 12 |
| Lily Pad Lake | August 6, 1937 | 23 | 6.5 | 2 | 10 | 6 |
| 105-mile Lake | 6 | 11 | 6.6 | 0 | 14 | 7 |
| Elliott Lake | 7 | 3 | 6 | 1 | 4 | 0 |
| 103-mile Lake | August 8, 1936 | 6 | 6.5 | 0 | 10 | 0 |
| Elliott Lake | 8 | 6 | 6 | 0 | 2 | 1 |
| Williams Lake | 11 | 10 | 5.5 | 0 | 2 | 30 |
| 130-mile Lake | August 11, 1937 | 3 | 4.3 | 4 | 2 | 6 |
| Fawn Lake | August 17, 1936 | 8 | 6.1 | 4 | 0 | 0 |
| Longbow Lake | 17 | 2 | 2 | 4 | 0 | 0 |
| Slough 2 acres | 22 | 1 | 5 | 0 | 0 | 0 |
| Slough 2 acres | 22 | 2 | 3.5 | 0 | 0 | 0 |
| Slough 6 acres | 22 | 6 | 4.1 | 0 | 0 | 0 |

swam past the brood. Meanwhile the mallard showed none of the maternal reactions usually displayed in the presence of danger, neither did she increase her swimming speed.

On 105-mile Lake a large raft of diving ducks in eclipse plumage, young ducks of various ages, and Holboell's grebes and coots were studied on a number of occasions. At times all were in close proximity but no act of aggression was observed.

The only instance of hostility on the part of a coot towards young ducks was noted at 149-mile Lake in July when a nesting bird splashed across the water

TABLE 2

SUMMARY OF DUCK BROODS AND ADULT LOONS, HOLBOELL'S GREBES, AND COOTS OBSERVED IN BRITISH COLUMBIA

| *Number of inspections* | | *Number of duck broods* | *Average number of young in the broods* |
|---|---|---|---|
| 15 | Loons, Holboell's Grebe, Coots present | 152 | 6.9 |
| 31 | Loons, Holboell's Grebe, Coots absent | 95 | 5.4 |
| 6 | Loons, Holboell's Grebe, only present | 33 | 6.8 |
| 1 | Loons, Coots, only present | 19 | 6.5 |
| 8 | Holboell's Grebe, Coots, only present | 63 | 6.3 |
| 35 | Loons present[1] | 292 | 6.4 |
| 73 | Loons absent | 354 | 6.1 |
| 36 | Holboell's Grebe present[1] | 298 | 6.5 |
| 73 | Holboell's Grebe absent | 238 | 6.0 |
| 54 | Coots present[1] | 410 | 6.4 |
| 54 | Coots absent | 238 | 6.0 |
| 12 | Loons only present | 85 | 6.4 |
| 3 | Holboell's Grebe only present | 16 | 8.2 |
| 27 | Coots only present | 148 | 6.5 |

[1] With or without the three other species.

and landed beside a brood of half-grown shovellers (*Spatula clypeata*). It assumed the characteristic pose of an excited coot—neck stretched out on the water and posterior feathers erected—but made no attempt to strike the ducks which showed little concern.

## DEAD WATERFOWL EXAMINED

The search for dead birds was carried on with considerable care each day of the nesting season and every part of an occupied area was covered systematically. None was found in 1937 and ten was the total for 1938. The majority were inconspicuous objects half submerged in the water; some had drifted into marsh cover; others were tangled in surface weeds or covered with filamentous algae.

It seems reasonable to suppose that the evidence of killings by loons, Holboell's grebes, or coots would remain available for some time unlike the evidence of true predation, for example by hawks, which usually consume the prey. Of the ten dead birds mentioned several were decomposed and had been dead a week or more. It is suggested that this total represents a large percentage of the young waterfowl killed by loons, Holboell's grebes, and coots in the area examined—assuming they were killed by one or another of these birds.

The following is a record of the dead birds examined:

A canvas-back (*Nyroca valisineria*) about ten days old was found floating in the marsh at Williams Lake on July 4, 1938. There was a contusion on the neck but the skin was not punctured; the stomach contained food. One loon and a number of coots were present on this lake.

A ring-necked duck (*Nyroca collaris*) and a buffle-head (*Charitonetta albeola*), both about ten days old, were found at Lily Pad Lake on July 6. The head of the buffle-head was crushed but the skin was not broken; on the face of the ring-necked duck was a long tear and part of the flesh had been eaten from the head. In both specimens the stomachs were well filled. One loon and

a number of coots were present on this lake.

A three-quarters grown Holboell's grebe, nearly as large as an adult but with wing feathers in sheaths, was found in the open water on 150-mile Lake on July 8. The frontal bones of the skull were broken. No loons were on this lake and it seems doubtful that any other of the water birds present could kill so large a bird.

Two canvas-backs about one-third grown, one downy Barrow's golden-eye (*Glaucionetta islandica*) and a downy eared grebe (*Colymbus nigricollis californicus*) were found on Sorenson Lake, July 9. The canvas-backs were too much decomposed to permit examination; the Barrow's golden-eye, which was probably two days old and small even for so young a bird, showed a patch of bare skin on the head and a bruised area on the back. The eared grebe, apparently hatched within two days, had a slight contusion on the head, the bare skin on top being red instead of the normal yellow. Both the golden-eye and the grebe had food in their stomachs. There was a large population of coots on the lake but no Holboell's grebes or loons.

A quarter-grown coot found at 105-mile Lake had been killed by a small puncture close to the vertebral column which penetrated the lungs. One loon and five adult Holboell's grebes were on the lake.

The waterfowl population of Anthony Lake on July 14 comprised one loon, apparently not nesting, one pair of Holboell's grebes, a female Barrow's golden-eye with eight young about three-quarters grown, a female lesser scaup (*Nyroca affinis*) with six young about one-fifth grown, and a female common mallard (*Anas p. platyrhynchos*) with six well-grown young. A young Barrow's golden-eye which was pierced through the breast and dead several days was found floating among the lily pads along shore; this may very well have been the work of a loon. When the lake was next visited on July 30 the single loon was still present; the female Barrow's golden-eye had left and her brood, now reduced to six, were nearly full grown with several able to fly. These were seen on various parts of the lake feeding among the lily pads. Two young buffle-heads one of which for a time was with an adult female, represented another scattered brood. In addition were: Eighteen young mallards; one brood of nine nearly full-grown ring-neck ducks and a second brood of seven about one-third grown.

No dead young, whose destruction might be attributed to loons or Holboell's grebes or coots, were found after July 21. It is probable that whatever loss may occur from this source takes place principally in the early part of the summer.

## DISCUSSION

A study of 108 waterfowl enumerations in the Cariboo region shows there is no appreciable difference in the size of broods when loons, Holboell's grebes, and coots are present and when they are absent.

The occasional instance shown in Table 1 of a low survival in duck broods associated with the presence of loons, Holboell's grebes, or coots is offset by other instances where a low average number is associated with their absence

or a high survival with the presence of one or another, or all three species. These differences are believed to be fortuitous; abnormal reductions in broods may be due to any one, or a combination of factors, including predators, parasites, diseases, or adverse weather conditions.

Attempts to obtain direct evidence of any of these species attacking young ducks (or young of their own kind) were unsuccessful; on no occasion did their presence cause any noticeable reaction on the part of female ducks or their young.

A systematic search of lakes and marshes during the period when broods of young waterfowl are probably most vulnerable to attack and suffer the highest percentage of loss, resulted in the finding of ten dead young. Two were grebes, one was a coot, and the remainder diving ducks. Seven of these showed punctures, contusions, or wounds of one kind or another that might have been caused by loons, Holboell's grebes or coots.

In general it may be said that mortality in young ducks appears to be highest in the first week or so of life; it is irregular; it does not follow any particular pattern but varies in different years and different localities. Probably it is related to some extent to the abundance or otherwise of suitable cover, which may be a factor not only in connection with losses through predation but also with those due to adverse weather conditions. It is suggested that in the Dry Belt a relatively greater loss occurs in drought years when cover is restricted. While it seems likely that some mortality can be attributed to attacks by loons, Holboell's grebes, and coots, this is undoubtedly casual or sporadic, and does not represent a serious drain on waterfowl production.

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# THE EFFECT OF PREDATOR CONTROL ON RUFFED GROUSE POPULATIONS IN NEW YORK

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Any subject involving relations of predators and game is most intricate—both from the biological and sociological aspects. Simple action and reaction observations are often grossly misleading. That phase of the subject dealing with control of the predators, and its value, is probably the most intricate of all. Our object has been to evaluate dispassionately the effectiveness of control on the prevalence of the predatory species themselves and on the ruffed grouse (*Bonasa umbellus*) populations. There is no axe to grind; the data must speak for themselves.

The predator control studies were made in southern New York on the Connecticut Hill Area in 1931–32, on Connecticut Hill and Bull Hill in 1934 and continued on Connecticut Hill in 1935. Two types of control experiments were made: "complete" control, under which all predatory species were taken and "selective" control, when only foxes (2 species) and weasels (2 species) were taken.

The initial experiment in 1931–32 on Connecticut Hill was designed to evaluate the effects of complete predator elimination. Of course such removal was far from accomplished, the degree of success with each species depending upon its trapping susceptibility and mobility. The area trapped consisted of 2,127 acres and included 1,425 acres of grouse coverts while the untrapped check area covered 1,956 acres with 1,223 acres of grouse coverts. The fact that these two areas lay adjacent to each other, one being the northern, the other the southern part of the study tract, unquestionably acted to reduce differentials in both grouse mortality and population. Hence, conclusions as to the positive effectiveness of predator control in improving grouse numbers probably are conservative.

A total of 557 predators was taken by trap or gun during this two-year period, 321 the first year (October 1, 1930–September 30, 1931) and 236 the second year (October 1, 1931–August 31, 1932). A statement of the numbers of animals taken each year is given in Table 1.

That this slaughter is no proud achievement, we are the first to admit. In deliberately attempting control of all predators, many acknowledgedly beneficial forms were taken. This indiscriminate policy was undertaken in the name of science for this experiment only and does not in any way represent the policy of the State of New York.

Records of predators taken the second year indicate that elimination was markedly successful on the long-eared owl, red-tailed hawk, and small brown weasel; moderately successful on the horned owl, marsh hawk, and crow. Species that showed little or no reduction the second year included, the Cooper's hawk, sharp-shinned hawk, sparrow hawk, red fox, gray fox,

[1] This study was made when the author was employed by the New York State Conservation Department and is part of the New York Ruffed Grouse Investigation.

TABLE 1

PREDATORS TAKEN ON CONNECTICUT HILL, 1931–32

| Birds | Number | | Mammals | Number | |
|---|---|---|---|---|---|
| | 1931 | 1932 | | 1931 | 1932 |
| Horned Owl (Bubo virginianus) | 34 | 22 | Red Fox (Vulpes fulva) | 8 | 9 |
| Barred Owl (Strix varia) | 1 | 1 | Gray Fox (Urocyon cinereoargenteus) | 2 | 6 |
| Snowy Owl (Nyctea nyctea) | 5 | — | Skunk (Mephitis nigra) | 31 | 35 |
| Long-eared Owl (Asio wilsonianus) | 11 | 2 | Small Brown Weasel (Mustela cicognanii) | 33 | 7 |
| Short-eared Owl (Asio flammeus) | 1 | — | New York Weasel (Mustela noveboracensis) | 2 | 1 |
| Screech Owl (Otus asio) | 2 | 1 | Domestic Cat (Felis domestica) | 3 | 10 |
| Saw-whet Owl (Cryptoglaux acadica) | 2 | — | Woodhuck (Marmota monax) | 25 | —[1] |
| Red-tailed Hawk (Buteo borealis) | 24 | 7 | Red Squirrel (Sciurus hudsonicus) | 25 | 40 |
| Red-shouldered Hawk (Buteo lineatus) | 4 | 1 | Raccoon (Procyon lotor) | 11 | 12 |
| Rough-legged Hawk (Buteo sanctijohannis) | 1 | — | Total | 140 | 120 |
| Broad-winged Hawk (Buteo platypterus) | 1 | — | | | |
| Cooper's Hawk (Accipiter cooperii) | 3 | 6 | | | |
| Sharp-shinned Hawk (Accipiter velox) | 5 | 8 | | | |
| Marsh Hawk (Circus hudsonius) | 14 | 7 | | | |
| Sparrow Hawk (Cerchneis sparveria) | 13 | 30 | | | |
| Crow (Corvus brachyrhynchos) | 60 | 31 | | | |
| Total | 181 | 116 | Grand Total | 321 | 236 |

[1] Woodchucks were not trapped the second year.

skunk, domestic cat, red squirrel, and raccoon. Considering only the more important grouse predators, control proved effective on the horned owl, crow, and small brown weasel; made little impression on the numbers of Cooper's hawk, sharp-shinned hawk, red fox, gray fox, skunk, and raccoon.

Even though some of the most important grouse predators remained as abundant the second year as the first, there may have been an immediate effect on the grouse due to the temporary reduction. Let us now turn to the grouse data and examine the mortality records for these two years for the trapped and untrapped portions of the area. These are summarized in Table 2.

In constructing this table, "Nest Mortality" was based on the fate of the nests located; "Brood Mortality" is the loss of birds in the broods up to three months of age; and "Adult Mortality" is the loss in adult population for the full year ending September 1.

These data indicate that predator

control reduced the nest mortality markedly both years. During the first year the brood and adult mortality records show a small differential favoring the trapped sections, but in the second year the brood mortality was practically identical on the two tracts and the adult mortality was actually higher on the controlled portion. Even though the predator control proved unable consistently to lower the brood or adult losses, it might seem that the reduction in nest loss should produce a higher shootable fall population. The September first population densities are given in Table 2, bottom line.

In the fall of 1931, while the area was still well below its carrying capacity in ruffed grouse, the predator-controlled portion did have a markedly higher population density. We believe that the increase in grouse, 25%, may be credited to the control of predators. Then the second year, with a nearly peak population at hand, the effect of the predator control was negligible. It appears, therefore, that the increase in mortality among adults on the controlled portion the second year, presumably brought on by the higher population density the first fall, almost completely offset the saving in nests. The value of the predator control in peak years then seems unimportant. But we must not overlook the fact that these were unshot areas. If the higher populations of grouse resulting from control of predators the first year had been utilized that fall by hunters, the effectiveness of predator control in increasing the productiveness of the reduced population might have continued unabated.

Following the two years of study of predator control in 1931 and 1932, a year was allowed to elapse and then

TABLE 2

RUFFED GROUSE DATA ON PREDATOR CONTROL SUB-AREAS CONNECTICUT HILL, 1931–32

| Type of Data | 1931[1] | | 1932[1] | |
|---|---|---|---|---|
| | Complete Control Sub-area 2,127 acres | No Control (Check) Sub-area 1,956 acres | Complete Control Sub-area 2,127 acres | No Control (Check) Sub-area 1,956 acres |
| Grouse Nest Mortality | 24.4% | 51.3% | 39.0% | 72.0% |
| Grouse Brood Mortality | 56.7% of 256 chicks | 66.7% of 147 chicks | 54.0% of 320 chicks | 55.0% of 280 chicks |
| Adult Loss—September 1 to August 31 | 10.9%[2] of 82 birds | 14.5%[2] of 69 birds | 31.5%[2] of 184 birds | 20.8%[2] of 120 birds |
| Grouse Population Density—September 1 (acres per grouse) | 7.70 | 10.19 | 5.34 | 5.55 |

[1] Full year ending September first of year given.
[2] Corrected from figures published in Annual Report of the New York State Conservation Department, 1932.

the experiment was resumed. With the possibility in mind that the results of the first trial may have been affected by extraneous factors within the two sub-areas, in the second series of tests beginning in 1934, the trapped and untrapped areas were reversed. If the results were similar to those first obtained, presumably the data would thus be proved comparable.

southern New York and are unprotected. Table 3 gives the data on predators taken on these two areas.

As in the earlier experiments, the outstanding species taken was the horned owl, which is probably the most efficient of the common grouse predators. Goshawks also appeared on the area in 1934 for the first time since the survey began (1930). The mammalian

TABLE 3

PREDATORS TAKEN ON CONNECTICUT HILL AND BULL HILL AREAS, 1933–34

| Birds (Connecticut Hill only) | Number | Mammals | Number | |
|---|---|---|---|---|
| | | | Connecticut Hill | Bull Hill |
| Horned Owl | 37 | Red Fox | 10 | 6 |
| Barred Owl | 1 | Gray Fox | 4 | 3 |
| Long-eared Owl | 1 | Skunk | 19 | |
| Short-eared Owl | 1 | Weasel (sp.) | 10 | 1 |
| Screech Owl | 11 | Domestic Cat | 4 | |
| Red-tailed Hawk | 10 | Woodchuck | 16 | |
| Rough-legged Hawk | 1 | Red Squirrel | 23 | |
| Goshawk (Astur atricapillus) | 3 | Raccoon | 6 | |
| Coopers Hawk | 4 | Mink (Lutreola vison) | 1 | |
| Sharp-shinned Hawk | 13 | Opossum (Didelphis virginiana) | 1 | |
| Marsh Hawk | 1 | Total | 94 | 10 |
| Sparrow Hawk | 1 | | | |
| Crow | 17 | | | |
| Total | 101 | Grand Total | 205 | |

Trapping was carried on from October 1, 1933 to April 30, 1934, instead of for the full year as previously. The 1934 experiments continued complete control with a no-trapping check area on Connecticut Hill while a selective control area was established on Bull Hill, five miles away, to test the effect on nest mortality of control of foxes and weasels. These animals appear to be the most destructive nest predators in

predators showed practically the same relative abundance as in the first experiments with the two species of foxes being most important.

During the 1934 experiments, the test areas were as follows: Connecticut Hill, complete control sub-area—1,956 acres including 1,223 acres of grouse coverts; Connecticut Hill, untrapped sub-area—1,568 acres total, 1,102 acres of coverts; Bull Hill, selective control

area—1,750 acres total and 1,167 acres of coverts.

The nest mortality on the Connecticut Hill sub-areas for 1934 was 20.0% for the trapped portion and 40.0% for the untrapped. The following summer, the brood mortalitities were 52.3% and 56.3%, respectively. Turning to the adult losses for the year, we are forced to utilize a different method of evaluation than before since the September 1933 population data are not complete, only a part of the area being censused in 1933. By adding known mortality records (i.e. grouse kills found) to the 1934 spring population figures and assuming that they represented birds taken from the sub-area on which they were found, we get a low but comparable estimate of the fall (1933) populations. By this method the loss of adults on the trapped area is calculated as 23.7% while that on the untrapped is 32.2%.

While reversing the trapped and untrapped areas we find that the results, too, are reversed. Accompanying control, nest mortality was lowered by one-half, brood mortality only very slightly reduced, and adult losses appreciably decreased. Hence, we conclude that the predator-control-effect data are reliable. If the comparability of data is valid, the 1934 fall population densities on the two sub-areas should show little difference, as was the case in 1932, since 1934 was another peak year. The density on September first on the trapped area proved to be a bird to 5.64 acres while on the untrapped portion the ratio was 5.51 acres per grouse, Thus, we find again that even in peak years effective reduction of nest mortality by predator control does not appreciably increase the fall "surplus" on unshot areas.

Turning to the Bull Hill tract, we note that the predator take consisted of nine foxes and one weasel. These were trapped between November 15, 1933 and April 30, 1934. The grouse nest census, in the spring of 1934, showed a mortality of 54.5%, considerably higher even than for the no-predator control sub-area on Connecticut Hill. Because this figure was based on only 11 nests, it may represent an incorrect average, but it is also true that loss of 3 of the 6 nests broken up was attributed to foxes. Thus, the control of foxes was unsatisfactory. The results of this selective control experiment were inconclusive.

With the completion of the 1934 Connecticut Hill experiments on complete predator control, the effectiveness of this type of control was thoroughly tested. Since the Bull Hill selective control experiment had not been satisfactory, the main objective of the 1935 experiments on Connecticut Hill was another check on fox-weasel control. But with the fall of 1934, a situation arose that seemed to present an unusual opportunity to get further valuable data on complete control. Section 3N, Connecticut Hill, attained a September density in grouse population of a bird to each 2.5 acres, equivalent to a grouse to each 1.8 acres of actual coverts, including no open land. This represented the highest population density any covert had been observed to attain. It was then decided to subject this section alone to complete predator control to determine if by so doing we could maintain this high population density. Indirectly, it gave us a better opportunity

to obtain data on dispersion or disease that might result in this heavy population.

The organization of the three Connecticut Hill sub-areas was then as follows: complete control—304 acres including 187 acres of coverts (Section 3N); selective control—1,152 acres total with 792 acres of coverts; check sub-area with no control—2,385 acres in all and 1,562 acres of grouse coverts. The predatory species taken during the 1935 trapping period, October 1, 1934 –April 30, 1935, totalled 121 individuals of which 97 were on the complete control sub-area and 24 on the selective control sub-area. These are tabulated in Table 4.

TABLE 4
PREDATORS TAKEN ON CONNECTICUT HILL, 1934–35

| Birds (Complete Control Sub-area) | Number | Mammals | Number | |
|---|---|---|---|---|
| | | | Complete Control Sub-area | Selective Control Sub-area |
| Horned Owl | 16 | Red Fox | 2 | 18 |
| Barred Owl | 2 | Gray Fox | 1 | 4 |
| Long-eared Owl | 1 | Skunk | 8 | |
| Screech Owl | 1 | Weasel (sp.) | 11 | 2 |
| Red-tailed Hawk | 5 | Domestic Cat | 12 | |
| Rough-legged Hawk | 3 | Woodchuck | 1 | |
| Cooper's Hawk | 1 | Red squirrel | 16 | |
| Sharp-shinned Hawk | 4 | Raccoon | 3 | |
| Marsh Hawk | 3 | | | |
| Crow | 7 | Total | 54 | 24 |
| Total | 43 | Grand Total | 121 | |

Most significant in this record is the take of horned owls and foxes, Furthermore, in contrast to the results on fox trapping on the Bull Hill area in 1934, the fox population on the selective control sub-area this year was eliminated with the exception of one red fox that occasionally came into the tract. This individual is known to have destroyed one of the thirteen nests found on the sub-area. The data on grouse losses for these three sub-areas are shown in Table 5.

While analysis of the data for 1935 is complicated by additional factors, the broad effects follow the same course as in previous years. Both complete and selective predator control proved effective in reducing nest losses. Because the complete control sub-area was small and only 3 nests were located, the data are not very substantial but do at least suggest effectiveness of the control in preventing nest mortality. The selective control having proved efficient this year, a reduction of about 40% in the nest mortality resulted. Turning to the effect on brood losses, we find again that little or no reduction was accomplished by either type of control—complete or selective.

The adult losses run exactly opposite to the objective, being greatest on the complete-control sub-area, and least on

the no-control sections. Because the losses on the complete-control section were accentuated by a marked dispersal of birds from the high population of the fall of 1934, examination of the known grouse decimation by predators would seem to give a fairer comparison. Based on grouse remains found, it appeared that nearly 20% of the 1934 fall population was destroyed on the complete-control sub-area, nearly 22% on the selective-control, and only 13% on the no-control, sections. Thus, in spite of drastic control of predators, the high population density on Section 3N still induced a higher rate of predation than occurred without control on the part of the area used as a check but which had a much lower population to start with. Thus the high decimation expected in peak populations seems to occur regardless of any elimination of predators that can be accomplished. The records for the selective control area also show that no reduction of adult losses was accomplished.

While the entire area had a reduced population density September 1, 1935 in comparison with the previous year, the reduction was least where no predator control was done. Compared with the higher percentage of reduction on the complete-control section, the lower loss on the check area is explained in terms of relations to population densities. The higher loss on the selective-control sub-area, which had a comparable density with the check area in 1934, is not so explained.

From the data at hand, we must conclude that predator control of either type tested, while sometimes markedly

TABLE 5

RUFFED GROUSE DATA ON PREDATOR CONTROL SUB-AREAS CONNECTICUT HILL, 1934–35

| Type of Data | Complete Control Sub-area 304 acres | Selective Control Sub-area 1,152 acres | No Control (Check) Sub-area 2,385 acres |
|---|---|---|---|
| Grouse Nest Mortality | 0.0% (Based on only three nests) | 23.0% | 37.4% |
| Grouse Brood Mortality | 70.6% of 68 chicks | 87.4% of 135 chicks | 78.9% of 336 chicks |
| Adult Loss—Sept. 1, 1934 to August 31, 1935 | 72.4% of 76 birds | 55.0% of 120 birds | 49.1% of 244 birds |
| Percentage of Sept. 1, 1934 population found killed in subsequent year | 19.7% | 21.7% | 13.1% |
| Grouse Population Density—Sept. 1, 1934 (acres per grouse) | 2.46 | 6.60 | 6.41 |
| Grouse Population Density—Sept. 1, 1935 (acres per grouse) | 4.56 | 11.14 | 8.15 |

effective in reducing nesting loss, did not produce a higher shootable fall population of grouse during years of high grouse abundance. In years of low grouse abundance during the upswing of the cycle, the evidence shows that predator control may appreciably increase the fall grouse population. But even under these conditions, with the grouse population increasing anyway, the justification for predator control is very doubtful. Whatever control might be thus justified would have to be far more discriminatory than that under which our results were obtained. The effectiveness of predator control in increasing grouse numbers during periods of cyclic grouse decline was not studied.

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# ON THE OCCURRENCE OF LEAD SHOT IN STOMACHS OF NORTH AMERICAN GRUIFORMES

*John C. Jones*

The importance of lead poisoning, resulting from the ingestion of shot, as a factor in the reduction in numbers of ducks in recent years is now recognized as a major problem in programs of waterfowl restoration in heavily hunted areas.

Although lead shot has been in use for several centuries, it was not until comparatively recent years that any harmful indirect effects upon wildlife received serious attention. Calvert (*5*), in 1876, published an account of lead poisoning in pheasants, caused by the swallowing of shot, and Holland (*10*), in 1882, described a similar case, but it was not until later that the malady was noted among waterfowl. Two anonymous notes in Forest and Stream (*1, 2*), and reports by Hough (*11*) and George Bird Grinnell (*7*), all in 1894, discussed the effects of lead poisoning in wildfowl. Grinnell (*8*) 1901, described the symptoms and effects among ducks, geese, and swans on Currituck Sound, North Carolina, and in several areas in Texas. In 1908 Bowles (*3*) gave an account of the trouble on the Nisqually Flats in the Puget Sound district, Washington, where a number of mallards were found sick or dead, and McAtee (*12*), in the same year, published a history of the disease among canvas-backs on Lake Surprise, Texas. Wetmore (*15*), 1919, published a bulletin on lead poisoning in waterfowl, describing, in detail, species affected, symptoms, effects, and other factors involved.

Since that time a number of short articles and papers have appeared dealing with the occurrence and prevalence of lead poisoning, largely among waterfowl, since they are, by far, the most commonly afflicted group of birds. All of these serve to emphasize the importance of the problem. Experiment with domesticated and captive birds has corroborated field observations and laboratory findings from stomach examinations. Brown (*4*), as early as 1904, reporting on digestion experiments with poultry, and Hanzlik (*9*), 1923, working with pigeons, described lethal doses, symptoms, and post mortem appearances for those birds. Wetmore's investigations in the above mentioned paper were conducted with mallards, pintails, and redheads, using wild birds that were captured when young and raised to maturity so that there could be no question of their ever having been previously affected by lead poisoning. His results showed that as few as six pellets of No. 6 shot were always fatal, and occasional deaths resulted when a smaller number were fed.

Cottam (*6*), 1939, described lead ingestion to an amazing extent among lesser scaups (*Nyroca affinis*), of which 365 (over 75.5 per cent) out of 477 birds collected at Lake Puckaway, Marquette, Wis. in the spring hunting season of 1909, contained shot, individual stomachs yielding from 1 to 58 pellets, with a combined total of 4,191 shot, and an average of 11.5 per bird. According to Pirnie (*13*), 1935, ten sick greater scaups (*Nyroca marila*) found at Houghton Lake, Mich. in the spring

of 1928 were sent to the University Museum at Ann Arbor, where Dr. Josselyn Van Tyne reported finding an average of nearly fifty shot in the gizzards. The deaths of five Canada geese (*Branta canadensis*) in Barry County, Mich. were also attributed to lead poisoning by the same author. Shillinger and Cottam (*14*), 1937, in an article on lead poisoning in waterfowl, told of destruction in many parts of the country, particularly the Atlantic Seaboard and the Middle West, based largely on field reports by members of the Biological Survey. Noteworthy was that of John J. Lynch at Columbia, S. Dak. where 113 dead mallards (*Anas platyrhynchos*) were picked up. Subsequent examination showed 103 of these to contain definite evidences of lead poisoning; as many as 38 pellets were found in a single stomach. An important part of this report dealt with the results of stomach analyses made in the Food Habits laboratory of the Biological Survey. Of 6,471 stomachs of diving ducks examined, 616, or 9.52 per cent, contained one or more pellets, while among the inland diving species of the genus *Nyroca*, frequency of their occurrence reached nearly 16 per cent.

Records of lead poisoning among the Gruiformes are somewhat scarce. Wetmore mentions the fact that hunters in the vicinity of Washington, D. C. commented on the presence of shot in the stomachs of rails, soras in particular being affected, but gives no definite instance of any bird having died from the effects of lead poisoning.

A report by F. M. Uhler[1] covering a rice field district along the Cape Fear River, about 12 miles south of Wilmington, North Carolina, September 27, 1925, describes considerable destruction of sora rails from lead poisoning: "The amount of shooting that had been done earlier in the season was graphically shown by the dozens of dead and dying Carolina rails (*Porzana carolina*) around the rice fields, which stomach examination showed to have perished from lead poisoning caused by shot picked up as grit while feeding in the fields. The stomachs of two sick rails were found to be ½ and ⅓ full of No. 6 and 8 shot."

To date there is a dearth of published material on lead shot in rail stomachs, and this paper is a contribution to information on the subject. It is intended merely to show occurrences in individual stomachs, and not actual cases of lead poisoning. The data used have been assembled from material being gathered for a study of the food habits of the Order Gruiformes, representing 1,977 stomachs, nearly all of which were examined by the author in the Food Habits laboratory of the U. S. Biological Survey. Material sufficient for good representation of some of the rarer forms is still lacking, but there is ample data to indicate tendencies of various species towards the ingestion of shot. All months of the year are well represented, and all sections of the country contributed material for the study.

Inasmuch as there is considerable dissimilarity of feeding methods in this group of birds, a difference in degree of ingesting shot would naturally be expected. Coots, with habits like those of ducks, are similarly exposed, but as they do not copy the ducks in sifting

[1] Uhler, F. M. 1925. Unpublished field report, in files of Section of Food Habits, Div. of Wildlife Research, Bureau of Biological Survey.

TABLE 1

OCCURRENCES, BY MONTHS, OF LEAD SHOT FOUND IN 1,977 STOMACHS OF NORTH AMERICAN GRUIFORMES

| Name of bird | Number of stomachs | January | February | March | April | May | June | July | August | September | October | November | December | Number of stomachs containing shot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grus canadensis canadensis | 9 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Grus canadensis tabida | 13 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Grus canadensis pratensis | 14 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Aramus pictus pictus | 30 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Rallus elegans elegans | 94 | — | — | — | — | — | — | — | — | — | 1 | — | — | 1 |
| Rallus longirostris crepitans | 245 | — | — | — | — | — | — | — | — | 1 | — | — | — | 1 |
| Rallus longirostris waynei | 102 | — | — | — | — | 4 | — | — | — | — | — | — | — | 4 |
| Rallus longirostris scotti | 23 | — | — | — | — | 1 | — | — | — | — | — | — | — | 1 |
| Rallus longirostris saturatus | 51 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Rallus longirostris obsoletus | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Rallus limicola limicola | 128 | — | — | — | — | 1 | — | 1 | — | — | — | — | 1 | 3 |
| Porzana carolina | 334 | 1 | — | 2 | — | 2 | 1 | 1 | 3 | 12 | 1 | — | — | 23 |
| Coturnicops noveboracensis | 16 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Creciscus jamaicensis stoddardi | 3 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Creciscus jamaicensis coturniculus | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Ionornis martinica | 18 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Gallinula chloropus cachinnans | 92 | — | — | 2 | 1 | — | — | — | — | 1 | — | — | — | 4 |
| Fulica americana americana | 801 | 5 | 1 | — | — | — | — | — | — | — | 3 | 2 | 1 | 12 |
| Total | 1,977 | 6 | 1 | 4 | 1 | 8 | 1 | 2 | 3 | 14 | 5 | 2 | 1 | 49 |

the bottom ooze, their chances of getting shot are greatly decreased. Gallinules, being largely dabblers, are normally exposed only when feeding along the edges of pools or in non-submerged portions of the marsh. Soras are probably more likely than any of the other rails to get shot in feeding, as a goodly portion of their food is made up of small hard seeds that they pick up at random. Of the long-billed species, the Virginia, clapper, and king rails, that probe for their food, are with the exception of the first-named, largely animal feeders, and not particularly likely to swallow lead pellets. There is little likelihood of the other members of the Order Gruiformes, the cranes and limpkins, finding lead shot in the course of their usual feeding habits.

These surmises are confirmed by stomach analysis. No occurrences of

lead shot were noted in stomachs of cranes or limpkins, and only a few among the king, clapper, and Virginia rails and the Florida gallinules; nearly all of the shot found were in stomachs of the sora rail and the American coot. No pellets were found in stomachs of the yellow and black rails, but the relatively small number of these on hand for examination precludes any definite statement as to the role of these birds in shot swallowing. A detailed summary of all occurrences, by months, is shown in Table 1. All months of the year are represented by one or more records of shot ingestion, but in no instance was the number of occurrences alarmingly high, or, with the possible exception of the sora, sufficient to indicate any danger of severe depletion in numbers of the species through lead poisoning. Only 49 occurrences, 2.5 per cent, were noted in a total of 1,977 stomachs, a figure not nearly approaching that of the 9.5 per cent noted by Shillinger and Cottam for all diving ducks, and 16 per cent for the inland varieties, and completely overshadowed by the Wisconsin record of 75.5 per cent among lesser scaups.

The number of pellets taken by individual birds varied, a single shot representing the commonest occurrence. Table 2 shows the number found in individual stomachs of soras and coots, the two species most commonly affected. Most birds had only one or two pellets, only two coots having as many as four. Four soras greatly exceeded this number, one containing remains of more than 55 shot. Of the four gallinule records, two were of four shot, one two, and the other one. The other scattered instances among the remaining species of rails were all of one apiece.

The small number present in most instances is in direct contrast with the large numbers reported from duck stomachs, but should not be dismissed too lightly, as the possible effects of sub-lethal doses in causing sickness and sterility must be admitted.

## SUMMARY

The number of lead shot picked up by members of the Order Gruiformes during their feeding activities is small, only 49 occurrences being noted from a total of 1,977 stomachs, collected in all parts of North America, and representing every month of the year. Nearly half of the records were supplied by the sora rail (*Porzana carolina*), this species being the only one of the group to which lead shot represent a potential menace, as many as 55 pellets being found in a single stomach. Among the other species, no single stomach contained more than four shot, the usual number being one, and the percentage of occurrence for each species uniformly low. It is doubtful if the larger forms, the cranes and limpkins, ever take lead shot.

TABLE 2

NUMBER OF LEAD SHOT TAKEN BY INDIVIDUAL BIRDS

| Number of pellets | 1 | 2 | 3 | 4 | 9 | 12 | 23 | 33 | 34 | 55 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sora | 6 | 7 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| Coot | 8 | 1 | 1 | 2 | — | — | — | — | — | — |

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# GRAY SQUIRREL UTILIZATION OF ELM

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A number of observers have noted the ability of gray squirrels to adapt their appetites to a wide variety of foods. John T. Nichols, (*Journal of Mammalogy*, February, 1927, pp. 55–57), records an interesting list of food plants used by gray squirrels in the vicinity of Garden City, Long Island, New York. Mr. Nichols noted that in late winter and spring, the buds and flowers of several species of trees were fed upon by gray squirrels. Of these, the buds of elm were usually sought in early April.

My own notes, taken in different localities indicate considerable usage of elm by gray squirrels. Over a period of the past eight years, in both Pennsylvania and New York, I have frequently noted gray squirrels feeding upon the samaras and flower buds of elm trees, *Ulmus*, in early spring. Though the period of availability of the succulent flower buds and seeds is short (usually lasting not longer than four or five weeks locally in the Northeast), they are eaten so avidly and in such quantities by gray squirrels to suggest considerable importance in the spring diet of these animals.

During April in the years 1931 to 1933, gray squirrels in the vicinity of Graterford, in Eastern Pennsylvania, were commonly observed feeding upon the flower buds and samaras of slippery elm, *Ulmus fulva*.

In Central and Western New York, gray squirrels were seen feeding upon the flower buds of American elm, *Ulmus americana*, on April 9, 16, 1939 near Ithaca, New York and again on April 12, 19, 1939 near Bath, New York. Feeding was usually observed between 10:00 and 11:00 A.M. on both cloudy and clear days. Later, at 6:30 A.M. on April 23, near Ithaca, five gray squirrels were seen feeding upon the flowers of one large elm while another was perched in an adjacent elm feeding upon the unopened flower buds.

The manner in which squirrels ate the flower buds is of interest. Often as many as two or three gray squirrels, foraging in the same elm crown, were seen to use their forepaws to bring the twigs within reach when they were quickly bitten through. Upon securing a twig the squirrels would immediately assume precarious sitting postures in the windswept crown, and use their forepaws to revert the terminal half of the twig, containing the buds, to their mouths. Still grasped in the forepaws, the twig was then revolved and shifted horizontally as the buds were consumed. This manner of feeding was strikingly similar to that of a human eating an ear of corn. The same technique was employed by all squirrels seen feeding on these buds in widely differing localities in New York.

In a period of fifteen minutes, one squirrel collected and ate the buds from 16 twigs. The twigs bore an average of six red-brown flower buds the size of large garden peas. Presumably almost 100 buds were consumed during this time. Many more would probably have been eaten had I not interfered by approaching the base of the elm tree to in-

spect the fallen, discarded twigs, when the squirrel leaped to an adjacent hemlock and disappeared.

Apparently the cutting of twigs to secure buds can have little more than a pruning effect upon elms. Twigs were cut cleanly, and few exceeded $\frac{1}{8}$" in diameter.

The degree to which both elm buds and samaras are relished by gray squirrels in parts of New York and Pennsylvania during spring suggests that, seasonally, *Ulmus* is an important gray squirrel food in these localities.

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# A FREAK DEER HEAD

*Ralph F. Honess*

On September 15, 1938 Dr. John W. Scott, former Secretary and Director of the Wyoming Game and Fish Commission, sent to this laboratory a freak deer head from Sheridan, Wyoming.

The malformation consisted of the unequal growth and development of antlers and an unusual number of large warts about the ears, eyes, and neck. These growths (Plate 28—A) were heavily pigmented fibrous nodules. Cross sections are shown in Plates 28—B and 29.

Histological preparations were made and sent to Dr. Margaret G. Smith, Pathologist of Washington University School of Medicine, who made the following diagnosis: "The tumor from the deer is a fibroma. It has occurred to me that this may be a tumor produced by a filterable virus, such as the fibromas and myxomas of wild rabbits."

Schilling (1938) says of deer on the Pisgah Forest, North Carolina, "Fibromous tumors and scabs of the epithelial tumorous type have been becoming increasingly common since 1934" (p. 251).

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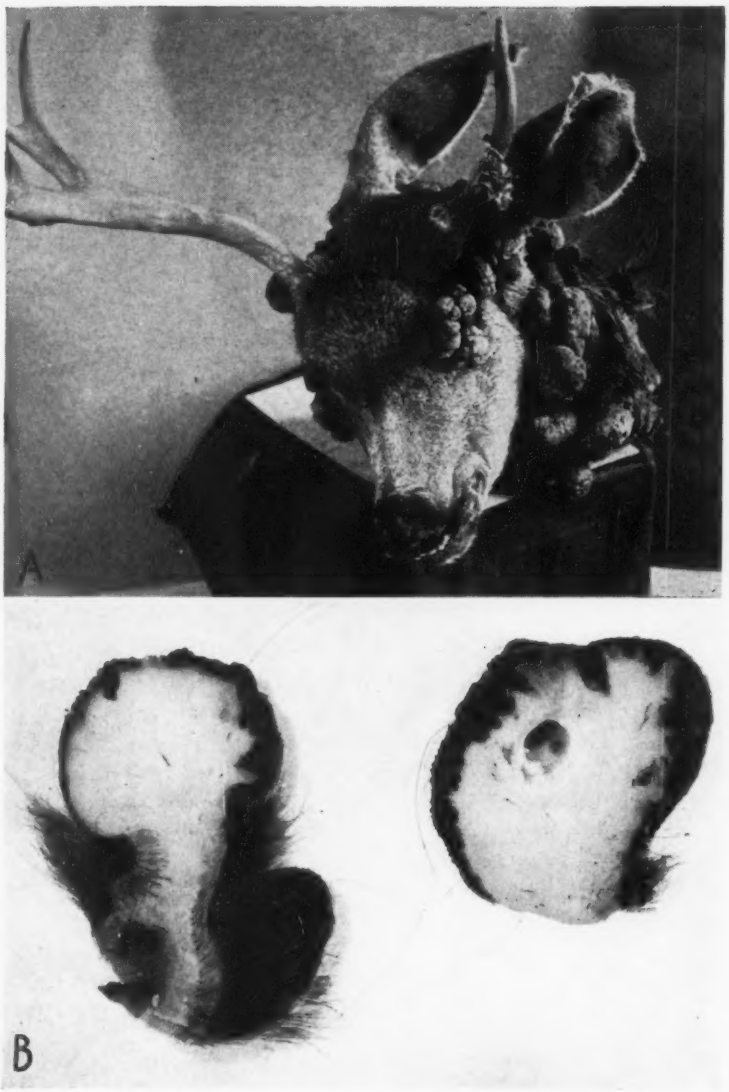
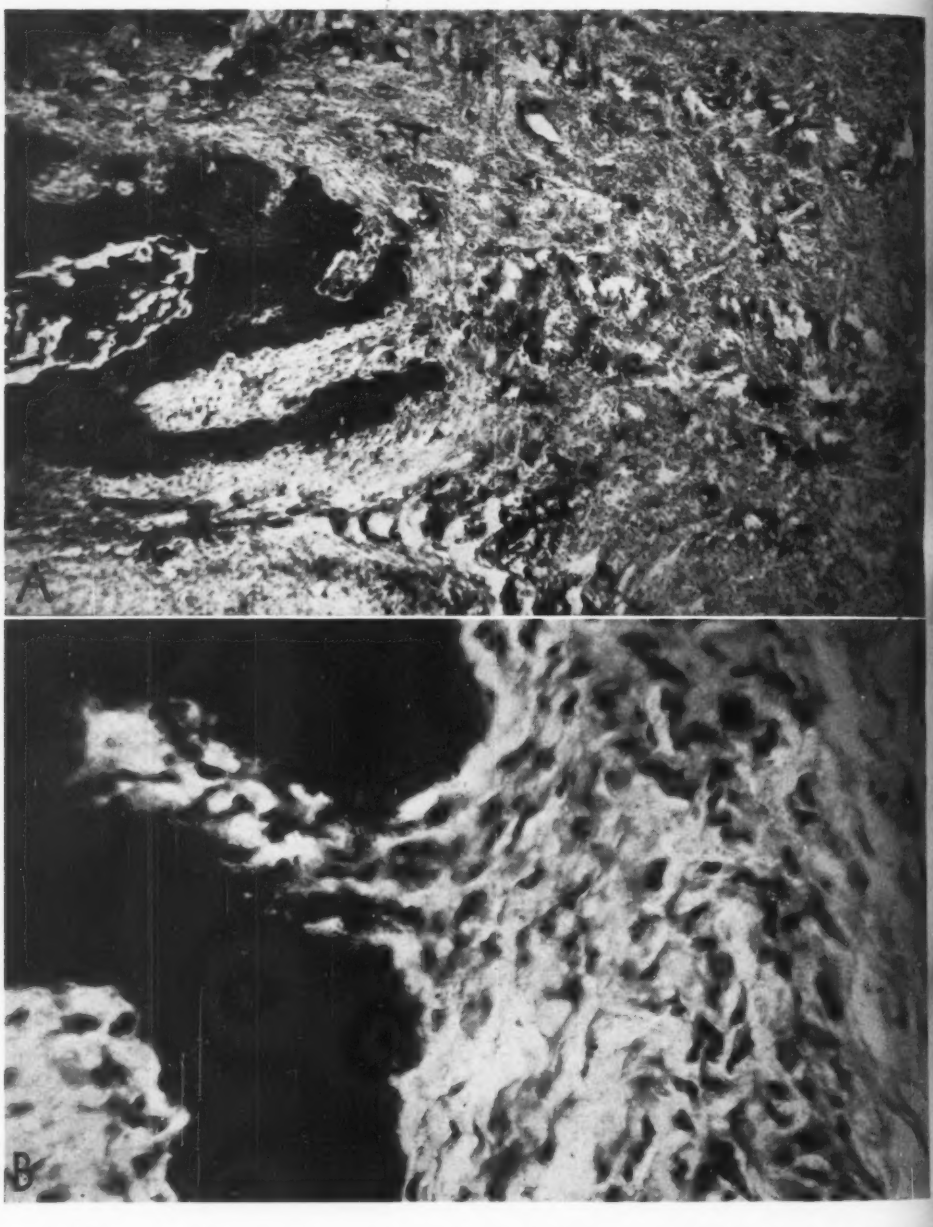



A. (*Upper*)—Deer head with fibrous tumors.
B. (*Lower*)—Cross sections of tumors (Natural size).




A. (*Upper*)—Low power photomicrograph of histological preparation showing pigmentation of epithelial layer and the tumor.

B. (*Lower*)—A higher magnification of part of the same section.

# A SPECIES OF PLASMODIUM FROM THE SHARP-TAILED GROUSE INFECTIVE TO OTHER BIRDS

*Psyche W. Wetmore*

While the writer was investigating the cause of loss of weight in prairie sharp-tailed grouse (*Pedioecetes phasianellus campestris*) sent from the Lower Souris Migratory Waterfowl Refuge, in North Dakota, two cases of plasmodia infections were found. A request for more material resulted in receipt late in March 1939 of a pair of grouse in one of which was found the parasite here described. Preliminary study of the infection revealed a plasmodium of the elongate gametocyte type forming four to eight merozoites.

A few weeks later an uninfected grouse (No. 320), two canaries, four bobwhites, and one pigeon were inoculated with citrated blood from the infected bird. One canary receiving an intravenous dose died the day following inoculation; the other receiving 0.2 cc. of blood intramuscularly failed to develop the infection, as did also the pigeon, which received 0.2 cc. intravenously. Three quail were inoculated intravenously and one intramuscularly. The intravenous inoculations resulted in infections, while the intramuscular inoculation gave negative results. When the inoculated grouse developed an infection two other canaries were inoculated from it, one intravenously and one intramuscularly, with positive results, as indicated in Table 1. The induced infection in the grouse reached an acute stage about 18 days after infection was first observed and resulted in severe anemia. The parasites at the same time began to have more effect on the host cell nucleus, displacing it to

TABLE 1

COMPARISON OF INFECTIONS PRODUCED IN DIFFERENT HOSTS

| Host | Host nucleus displaced | Prepatent period | | Patent period | Crisis | Pathogenicity | Parasite level | Time of peak of segmentation | Location of segments | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Intramuscular | Intravenous | | | | | | | |
| Grouse 1 (natural infection) | None to slight | | | 3 months | | None | Moderate | 9 to 10 A.M. | Polar, some exceptions | |
| Grouse 320 | None to slight | | 19 days | 8 weeks | 10th day | Death in 8th week | High | 8 to 9 A.M. Some at all hours | Polar or lateral | |
| Grouse 334 | Slight | | 6 days | 4 to 12 weeks | 9th day | No effect by 14th week | High | Morning | Polar or lateral | |
| Bobwhite (3 cases) | None | | 11–55 days | 3 weeks to 2 months | None | None | Low | No peak, some at all times | Polar | Adult gametocytes tend to be narrower than in grouse |
| Canaries (5 cases) | None | 19 days | 5–14 days | 6–21 days variable | None | None | Very low | None | Polar or lateral | |
| | | Intraperitoneal 14 days | | | | | | | | |

such an extent that it appeared as if this were a mixed infection. Consequently three additional canaries and one grouse (No. 334) were inoculated with blood from grouse No. 320. Grouse No. 334 had been used in an experiment with another species of plasmodium and had apparently recovered. These inoculations resulted in three canary infections no different from those of the first two canaries inoculated from grouse 320, and a grouse infection differing from the first only in a shorter duration of the prepatent period. From these results it was concluded that this was a single strain of plasmodium, which possibly was more destructive to the erythrocytes of the natural host than to those of the experimental birds.

Morphology in the naturally infected grouse: The trophozoites are oval or lance-shaped; may be ameboid; have one conspicuous black or brown granule at one pole, sometimes appearing to be outside the parasite; and often have a central vacuole and chromatin at margin. Trophozoites may be found at all times.

Schizonts are usually located at poles of the host cell, especially when segmentation is nearly complete, and form 4 to 12 merozoites—the usual number being 7. The pigment is collected in one large granule. The host cell nucleus at this stage may be tilted but not displaced. These are found at any time during the day but seem to be more numerous between 8 and 9 o'clock in the morning. Forms are seen, though rarely, in which merozoites separate and completely surround the host nucleus, as described by Wolfson (1938) in *P. oti* infection of the canary.

The gametocytes are elongated, frequently curved about one or both ends of the host cell nucleus, sometimes wider at one end than at the other, and occasionally round at one end and square at the other, especially before they are fully mature. The inner margin is often irregular. Some forms are seen which are so broad as to cause slight lateral displacement of the host cell nucleus. These stages resemble *Hemoproteus* sp., but since they were transmitted by blood inoculation to two hosts of the same species they are considered to be Plasmodium. The pigment in the gametocytes may be in several large bacelloid granules located in either pole or may be fine and scattered. There are seldom more than 9 granules, and the average is about 5.

With Giemsa stain the nucleus is pale pink, centrally located, and elongate in shape. The macrogametes stain light blue with scattered chromatin, and the microgametes take scarcely any stain at all, appearing hyaline. As a rule, the microgamete has a few coarse pigment granules located in the poles. In the macrogamete the pigment is more scattered.

Morphology in the eastern bobwhite (*Colinus v. virginianus*): The morphology of the parasite in the eastern bobwhite is the same as in the grouse, except that the gametocytes are narrower. No forms broad enough to fill one side of the host cell were observed. This may be due to the fact that there was no acute stage in the quail and that the parasite level was never so high as in the grouse. This was also true of the canary infections which were even lighter than those in the quail.

Pathogenicity: Under the best con-

TABLE 2

COMPARISON OF CANARY INFECTION OF *P. HEXAMARIUM*, *P. OTI*, *P. VAUGHANI* AND *P. POLARE* AND PLASMODIUM FROM PRAIRIE SHARP-TAILED GROUSE

| Characteristics | *P. hexamarium* (After Huff 1935) | *P. oti* (After Wolfson 1936) | *P. vaughani* (After Manwell 1935 a) | *P. polare* (After Manwell 1935 b) | Plasmodium sp. from Grouse |
|---|---|---|---|---|---|
| TROPHOZOITE. | Ameboid or not, chromatin near periphery. Cytoplasm often vacuolated. | | Often ameboid. Often so vacuolated as to appear ring-like. | Usually lateral. | Lance-shaped or ameboid. Chromatin near periphery. Often vacuolated. |
| Pigment. | 2 small granules. | | 1 to 3 granules, 1 large and refractile. | | 1 large granule. |
| SCHIZONTS. | No larger than host cell nucleus. Chromatin in masses connected by strands. | Elongate, located parallel to long axis of host cell. | Often polar. | Nearly always polar. | Often polar, especially when segmenting. |
| Pigment. | Clumped. | Concentrated in one place. | | Clumped and often pushed aside; oval. | Clumped. |
| Merozite number. | 6, rarely 8, elongate or rounded. Chromatin peripherally distributed in thick ring. | Usually 8. | 4, often 6 or 8. | 8 to 14, average 10.5. | 4 to 12, average 7. |
| Peak of Segmentation. | Morning. | | | | Morning. |
| Periodicity. | Probably tertian or quartan. | | None. | | None observed. |
| GAMETOCYTE. | Pole to pole of host cell, ends curved. Nucleus round or long. | Elongate, tending to bend around both poles of nucleus. | Sometimes ameboid processes. | Resemble Hemoproteus. | Narrow in canary, wider in grouse. May curve about host cell nucleus causing some lateral displacement by larger forms. |
| Pigment. | Dispersed, granules large bacelloid. | Rod-like, polar in young gametocytes, scattered in adults. | | Average 7 granules; generally oval. | Pigment coarse, generally. Average 5 to 9 granules. |
| Effect on host cell nucleus. | None. | Not displacing host cell nucleus.[1] | | None, or very slight, by broadest forms. | |
| INFECTION. Prepatent period. | 3 months when first isolated. 5 to 12 days after several passages. | Intravenous, 5 days. | Intramuscular, 3 weeks or more. Intravenous, 7 days. Variable. | 1 week to 2 or 3 months. | Intramuscular, 19 days. Intravenous, 5 to 14 days. |
| Patent period. | 2 to 3 weeks. | Often long (Manwell, 1938). | Several weeks or longer. | 2 or 3 days or less. | 6 to 21 days. Variable in canary. |
| Number of parasites in peripheral blood. | Very small. | Low (Manwell, 1938). | Low. | Very few. | Very low. |
| PATHOGENICITY. | | | Slight. | Slight. | Not pathogenic to canary. |

[1] Figure 16 of plate 1, page 101, shows some lateral displacement.

ditions, the life of the sharptailed grouse in captivity usually is not long. The naturally infected bird has apparently been in good health since it has been in our care—four months. How long it harbored the infection before we received it is not known. One experimentally infected grouse died. Although the parasite level was still high, death did not occur at the crisis of the

infection, but four or five weeks later. Death was apparently due to intestinal stasis. The other experimentally infected bird is in the fourteenth week of the infection at the time of this writing with no symptoms apparent. Conclusions regarding pathogenicity may safely be made only after a large number of natural infections are studied.

Comparison of the infections in five canaries, three quail, and three grouse are given in Table 1. Table 2 summarizes the characteristics of the species from the grouse and four similar species, the descriptions being taken from the author's notes and drawings.

No species of plasmodium has been described from the grouse, according to the check list of this genus by Coatney and Roudabush (1936). Only two species are listed from the order Galliformes, *P. malariae raupachi* Parcvanidze from *Meleagris* species, a description of which has not been located in this country, and *P. gallinaceum* Brumpt, from the domestic chicken. The parasite here described from the grouse differs from *P. gallinaceum* in having a smaller number of merozoites and in being infective to canaries. Of the nine species of avian plasmodia recognized by Manwell (1938) as valid, all have been isolated from passerine birds. *Plasmodium capistrani*, from the island painted quail (*Excalfactoria lineata*), Russell (1932), has since been studied by Manwell (1936) in canaries, and because of the similarity of the infection in that host is considered to be synonymous with *P. praecox*. Since host specificity in avian malaria is slight, the type of infection produced in the canary and cross-immunity tests is the basis for determining species.

The grouse parasite when inoculated into canaries has points of similarity to four described plasmodia of the elongate gametocyte type. In the matter of merozoite production it seems to stand between *P. polare* and *P. hexamarium* in numbers, never having as many as 14, but not regularly 6 as has *P. hexamarium*. With these comparisons tabulated and the photographs made illustrating morphology (Plate 30), the author wishes to await the outcome of cross-immunity tests to determine whether this grouse plasmodium is a new species or merely a variety of one of the previously described species.

Conclusion: No species of plasmodium has been previously reported from the prairie sharp-tailed grouse. This grouse plasmodium is characterized by elongated gametocytes that displace the host nucleus slightly when fully mature by producing from four to twelve merozoites, and by being transmissible by blood inoculation to the bobwhite and to canaries. The results of cross-immunity tests are awaited to determine its relationship to similar described species.

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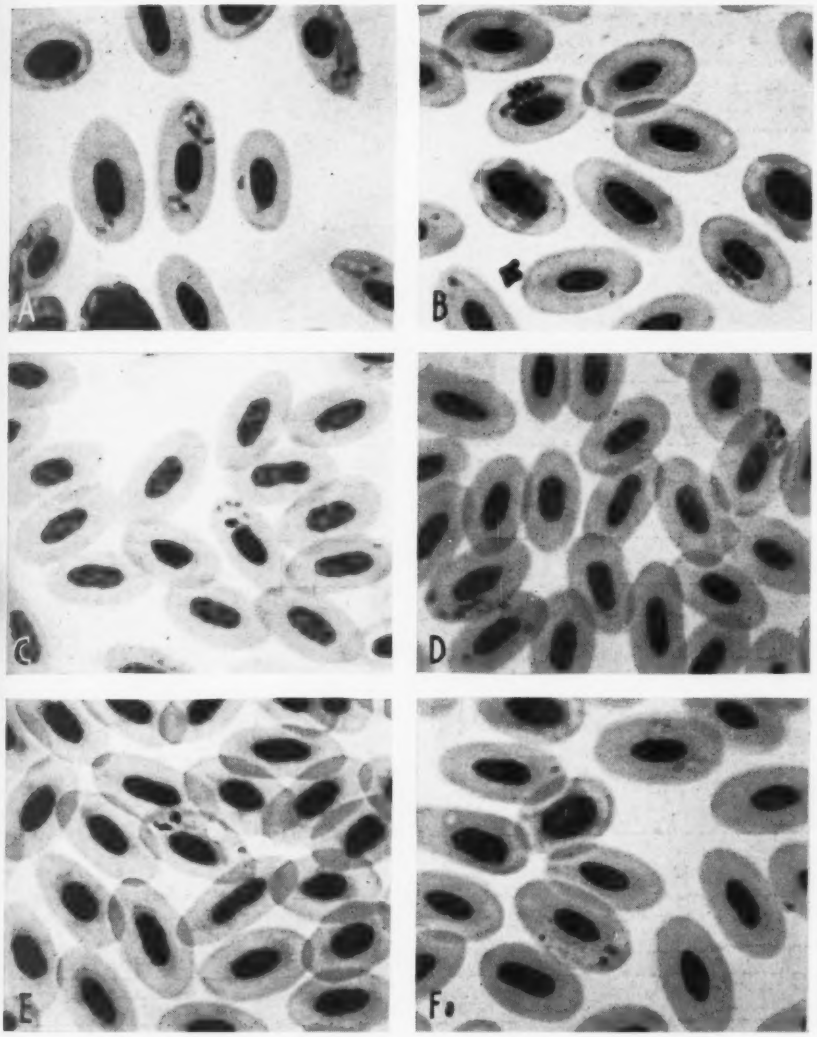


Fig. A. Grouse infection at crisis. Two macrogametes showing irregular distribution of chromatin and host cell nucleus crowding. A trophozoite in right hand corner with conspicuous granule and chromatin at margin. One cell with double infection.

Figs. B, C, and D. Schizogony. Note polar positions in C and D.

Fig. E. Macrogamete in quail infection.

Fig. F. Microgamete not quite mature.

(Photomicrographs ×1400)

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U. S. Biological Survey
Washington, D. C.

# OBITUARIES

The death of Joseph Grinnell, Director of the California Museum of Vertebrate Zoology, removed from the rolls of the Wildlife Society one of its best known members. A little over 62 years of age, he was still in the full stride of accomplishment when overtaken by illness in late August of 1938.

He died May 29, 1939, at his home in Berkeley, California, of a coronary occlusion. He was born, February 27, 1877, at old Fort Sill, Oklahoma (then Indian Territory), the son of Dr. Fordyce Grinnell, M.D., and Sarah Elizabeth (Pratt) Grinnell. His mother was the author of many papers and books on a variety of subjects including ornithology. Through each parent his ancestry stems back to the Taber family of New England. He was predominantly English but had some French Huguenot blood. On June 22, 1906, at Glendora, California, he married Hilda Wood. He is survived by her, their four children, Willard Fordyce, Stuart Wood, Richard Austin, Mary Elizabeth, and by a younger brother Fordyce.

He attended Pasadena (California) High School, received the A.B. degree in 1897 from Throop Polytechnic Institute (College) [now California Institute of Technology], and from Leland Stanford Junior University he received the M.A. degree in 1901 and the Ph.D. degree in 1913.

Biographical data for J. Grinnell, stressing features of his work related to fields other than wildlife management have recently appeared in Science, **90**: 75–76, 1939, Bird Lore, **41**: 238–239, 1 fig., 1939, The Murrelet, **20**: 46–47, 1 fig. 1939, and it is expected that fuller accounts will appear in next year's volumes of "The Auk" and "The Condor" and in an early number of the "Journal of Mammalogy."

His reputation as an all around naturalist is firmly founded on extensive researches and publications relating to ornithology, mammalogy, geographic distribution, speciation, and conservation of our natural resources, in the ways that he judged would be useful on a long-time basis. Of the more than 550 papers and books which he wrote, fourteen chronologically arranged, as follows, relate to wildlife management: Foolish Introduction of Foreign Birds, Condor, **8**: 58, 1906.—The Outlook for Conserving the Band-tailed Pigeon as a Game Bird, Condor, **15**: 25–40, 1913.—Game Legislation (with W. F. Badè), Berkeley Civic Bul., **1**: 87–88, 1913.—Bats as Desirable Citizens, Pacific Rural Press, **85**: 344–345, 1913.—Bird Life as a Community Asset, Calif. Fish and Game, **1**: 20–22, 1914.—The Game Birds of California (with H. C. Bryant and T. I. Storer), Univ. Calif. Press, 8 vo. x+642 pp., 94 text figs., 16 col. plates, 1918.—Natural History of the Ground Squirrels of California (with Joseph S. Dixon), Calif. State Comm. of Horticulture, Monthly Bul., **7**: 116 pp., 30 figs., 5 col. plates, 1919.—Risks Incurred in the Introduction of Alien Game Birds, Science, n.s. **61**: 621–623, 1925.—The Burrowing Rodents of California as Agents in Soil Formation, Smithsonian Rep. for 1923, pp. 339–350, 3 pls.,

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Although he published thus on conservation, and generally retained a conservation-minded economic zoologist on the museum staff, and disseminated many ideas about conservation in his course, "Applied Vertebrate Zoology," really his share in preserving and managing the native fauna and flora was mainly accomplished by more indirect means. He liked to inspire the beginning of a movement, then sit back and watch it grow, fully content with, and even desirous of, anonymity for himself. His part with C. M. Goethe in inauguration of the nature guide service in national parks when Stephen T. Mather was Director; the impetus and direction (later changed) he gave to rodent control by publishing, with Joseph S. Dixon, the "Natural History of Ground Squirrels of California," in 1917, and by serving as consulting zoologist for the horticultural commission in 1918; his influence in shaping the California Fish and Game Code, and the share he took in formulating the policy concerning California state parks, indicate some fields of his influence. The backbone of his method was first the early presentation of biological facts that served as guide posts for administrative action and, second, commendadation, in personal correspondence, of constructive action taken by officials. Only twice, so far as I know, did he take part in initiating opposition campaigns, and then only after he had exhausted other means of solving the problems. His first venture of this kind was in the period 1910–15 when, with Walter P. Taylor and Harold C. Bryant as associates, he actively opposed the inadequacy of the then existing California statutes protecting wild game. Although at first defeated in his efforts, and finally in a measure silenced by attempts of his opponents to exert political pressure, he before long saw the "no sale of game" concept and other reforms espoused by him enacted into law, and more than that, these concepts today are taken for granted as fundamentals in game legislation. The second venture was between 1930 and 1935, when, with Jean M. Linsdale and myself as assistants, he opposed the extension of control (reduction) of wild mammals to public and uncultivated lands, the use of the cumulative poison thallium, and organized bird control.

In the field Joseph Grinnell was a prodigious worker. He collected 20,281 specimens of vertebrates exclusive of fishes and after 1908 wrote 3005 pages of field notes. In the Museum of Vertebrate Zoology, founded in 1908 by Miss Annie M. Alexander, he as director, for over 30 years, devised and maintained an unexcelled system for safeguarding specimens and facts and for making them instantly available when wanted.

He was a member of at least 34 scientific societies, in many of which he occupied responsible offices. For example, he was a past President of the American Ornithologists' Union and of the American Society of Mammalogists. Also, he was an honorary member of the Linnaean Society of New York, Fellow of the American Academy of Arts and Sciences, and Correspondent of the Academy of Natural Sciences of Philadelphia. His mature wisdom and fairness were recognized at the University of California where, as a result, he was appointed to serve on many important committees.

Professor Grinnell was an eminent teacher. Although a number of the investigations by his pupils dealt with economic zoology, he stressed always that completion of the investigation so as to ascertain biological truth was the ideal goal and something far more important than the direction in which the problem ultimately led the investigator.

From among the great number of his pupils now engaged in biological work of various sorts, I can recall the names of the following who have been identified with wildlife management: Joseph S. Dixon, Harold C. Bryant, Walter P. Taylor, Tracy I. Storer, Shaler E. Aldous, Adrey E. Borell, E. Lowell Sumner, Jr., Clarence E. Smith, Henry S. Fitch, Raymond M. Gilmore, Benjamin H. Thompson, Donald M. Hatfield, Lawrence V. Compton, and William B. Davis.

Joseph Grinnell's progressively retiring nature in later years reflected the fine sensibility of the man. He was highly helpful to others, especially those younger than himself that he judged had real interest in biology. The high value placed by him upon thoroughness and accuracy, and his insistence upon high standards in work that he directed, combined with the aforementioned attributes, earned him the respect and deep affection of his associates.—E. RAYMOND HALL.

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With the passing of Dewey Richmond Mast, biologist and conservationist, at Charlottesville, Virginia, on August 3, 1939, the U. S. Soil Conservation Service, the State of Virginia, and the entire South, lost a leader in the field of wildlife conservation. Born at Rufus, North Carolina, May 15, 1903, he was one of the best known and most beloved men in his profession. His good nature and easy cordiality endeared him in the hearts of his associates.

He leaves a devoted wife (Jeneva Dean Mast), and legions of friends who knew and valued his good fellowship and earnestness in the cause of wildlife conservation.

After graduating with an A.B. degree in 1929 from Elon College, he received his M.S. degree, with major in zoology, in 1934 from North Carolina State College, Raleigh. He was a biology teacher in the city schools of Newton, North Carolina, from September 1931 to May 1932. Following this, he was principal of the high school and biology teacher at Lenoir, North Carolina, where he served until May 1935.

In August 1935, he was appointed assistant technician in wildlife management in the Civilian Conservation Corps at High Point, North Carolina, and in October 1935, junior biologist with the Soil Conservation Service. In

October 1936 he was promoted to assistant biologist in that organization and was serving in this capacity in Charlottesville at the time of his death.[1]

[1] By his own hand, perhaps in apprehension of hereditary insanity; no outward signs were ever noted, however, by the friends of this apparently most healthy, whole-souled, and jovial character.—W. L. M.

Sportsmen, conservationists, and the public, little realize the great and lasting contribution which Mast made to conservation in his lifetime. Few will ever fully appreciate and know of his years of devoted effort to bring understanding of nature's laws, and the need to conserve that which nature alone can give us.—ROSS O. STEVENS.

## NOTES

Classifying general articles that have appeared in THE JOURNAL OF WILDLIFE MANAGEMENT, the Editor obtained the following result:

| Character of paper | Volume | | | Totals |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Primarily on management | 1 | 9 | 6 | 16 |
| On research with management applications indicated | 5 | 5 | 5 | 15 |
| Primarily on research | 4 | 21 | 30 | 55 |
| Others | 1 | 1 | 7 | 9 |
| Totals | 11 | 36 | 48 | 95 |

It is apparent that articles primarily on research have been increasing not only absolutely but also proportionally: 36.3%, 58.3%, 62.5%. While some of these contributions have dealt with census methods—necessary tools of management—the trend has been away from what would seem proper for a journal of wildlife management. If this view is shared by members of The Wildlife Society, let them contribute more papers on management. The character of the magazine is controlled by the nature of the material received.

Shaler E. Aldous has recently supplied a corrected legend for figure 2 in his article "Beaver Food Utilization Studies" published in THE JOURNAL OF WILFLIFE MANAGEMENT 2(4), October 1938, pages 215–222. It is as follows:

Curve for computing the weight of bark and twigs from the tops of aspen trees that have a d.b.h. in excess of 7 inches, according to the diameter at the upper cut when the bark of the lower trunk is not eaten.

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To assure publication of articles in THE JOURNAL OF WILDLIFE MANAGEMENT in the order of their receipt, the plan was adopted of sending them to the printer in lots corresponding to numbers of the JOURNAL. Under this method, it has proved impracticable to achieve regularity of issue for the principal reason that one author or another could not return proof except after considerable delay. Another plan will now be tried, namely, that of sending copy at convenient intervals to the printer who will set it up, despatch proof, and hold the type. Numbers of the JOURNAL will then be made up from proofs that have been returned. Priority will still be observed, so far as

practicable, but printing of the JOURNAL will not be held up awaiting delayed copy. With this procedure, it is hoped to have the JOURNAL mailed during the first week of the month in which it is due.

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Issues of THE JOURNAL OF WILDLIFE MANAGEMENT will be reduced in size in 1940 unless members of The Wildlife Society and other contributors send in manuscripts at an accelerated rate. The prospect is that all on hand will be used in the January number.

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### MIDWEST WILDLIFE CONFERENCE

The Fifth Annual Midwest Wildlife Conference will be reduced in size in Hotel, St. Paul, Minnesota, on December 1 and 2, 1939. All members of the Wildlife Society are invited to attend and to participate. In addition to the states usually represented at this conference, representatives from North and South Dakota, Nebraska, Kansas, and other western and southwestern states especially are urged to come.

Papers covering unpublished current developments in wildlife management will be welcome. The conference will be divided into three sections; Dr. Gustav Swanson, Division of Entomology and and Economic Zoology, University Farm, St. Paul, will be in charge of that relating to small game; Dr. Samuel Eddy, Department of Zoology, University of Minnesota, Minneapolis, will be chairman of the section on fishes, and Harry D. Ruhl, in Charge, Game Division, Department of Conservation, Lansing, Michigan, will preside over the meeting devoted to big game and fur animals.

Titles and brief abstracts of proposed papers should be in the hands of the section chairman not later than November 15. To assure time for discussion, speakers are asked to condense their presentations to fifteen minutes. Publication of the proceedings is not contemplated and the reading of papers at this conference, therefore, will not interfere with their being presented or published elsewhere.

Professor Aldo Leopold will address the conference at the banquet to be held on the evening of December 1st.

Gordon Fredine, Division of Game and Fish, St. Paul, Minnesota, is in charge of general arrangements and notice of intention to attend the conference and requests for more detailed information should be addressed to him.